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OPERATIONS RESEARCH IN A NEW SPANISH AIR FORCE PLANNING SYSTEM

THESIS

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AFIT/GOR/ENS/91J-02

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This process can allow high flexibility, be helpful facing the budgetary problems for all the Air Forces, and also can be easily integrated in a joint defense system.
The path defined in this thesis is able to be adapted for different situations. It can be useful for other Services or countries, when their own peculiarities have been set up on the defined process.
The system could be used in two different ways: First, it can be useful defining the capabilities of the Air Force. Secondly it helps to define a Force Structure for the country, once the political commitments have been defined. This thesis can be included in the second case, when it is considered the aquisition of a new weapon system for the replacement of an old one maintaining a similar Force Structure.
In this specific case, the system has been applied to determine, among two alternatives, which new weapon system could be more effective for the current Spanish Air Force.

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OPERATIONS RESEARCH IN A NEW SPANISH AIR FORCE PLANNING SYSTEM

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science (Operations Research)

Antonio Valderrabano Lopez,
Lieutenant Colonel, Spanish Air Force

June, 1991

Preface

This thesis applies Operations Research techniques in a new model for the Spanish Air Force Planning System. The overall objective of this thesis is to find a system which reflects the Air Force capabilities, the tasks that it could carry out, and be useful in a Force Structure definition.

The viewpoints presented in this study are not intended to reflect the points of view of any of the agencies, organizations or goverments referred to in the study.

I would like to thank my thesis advisor, Major Bruce W. Morlan, for his great help in this effort, without which it may never have been completed. I would also like to thank Lt. Col. Curtis R. Cook for his guidance and Ernest R. Keucher for his linguistic adjustment. Finally, I would like to thank my wife Mercedes and my chidren, for their patience and support.

Antonio Valderrabano Lopez

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Abstract

The focus of this research effort was to determine a new Spanish Air Force Planning System. Today's highly technological weapon systems are very expensive, and resources are very scarce. So its selection has to be done very carefully.

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The path defined in this thesis is able to be adapted for different situations. It can be useful for other Services or countries, when their own peculiarities have been set up on the defined process.

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OPERATIONS RESEARCH IN A NEW SPANISH AIR FORCE PLANNING SYSTEM

I. Introduction

1.1 Generalities

Current political events around the world, such as the new relationship between the United States of America and the Soviet Union, and the changes that are happening in Europe and the Middle East, all show that an important challenge is going to be confronted by all contemporary national societies, particularly their armed forces. Due to the scarcity of resources, the constant reductions in defense budgets of developed countries, and the huge prices of military material, it is very important to define carefully and plan the acquisition of future assets for the Armed Forces and, in particular, for the Air Forces. In this context, the Spanish Air Force is facing a fascinating and important problem. That problem is to set up a new Planning System useful for supporting responsibilities to itself and to NATO.

In the current situation, the Air Force staff has to be very careful when planning, mainly at medium and long term, and then deciding what capabilities the Air Force will need to have in the future, under uncertainties of expected events in the world. They need to employ the best techniques today in order to get the most efficient Air Force for tomorrow.

1.2 Objective

The purpose of this thesis is to demonstrate a new Planning System tool for the Spanish Air Force, using Operations Research and System Analysis Techniques, which can help in the determination of the most efficient methods for the future fulfillment of the missions of the Spanish Air Force, as well as in the definition of new weapons systems for the necessary replacement of current weapons system.

1.3 Research

The process to be followed in this thesis consists of the following steps:

1. A review of the USAF, NATO and Spanish procedures, identifying their respective missions and planning systems.
2. A definition of an appropriate planning procedure for the Spanish Air Force.
3. A demonstration of how this approach could be used to select a follow-on fighter replacement for the current Mirage F-1.

1.4 Methodology

In the literature review, the Spanish and NATO Planning Systems, and the USAF doctrine, particularly on USAF Mission Area Analysis, are reviewed. This will provide a basis for understanding the three systems.

After a review of the Spanish, NATO and USAF planning systems, this thesis will suggest a new Planning System, in which may be found similar ideas, but with new implications and concepts. We will do that because we would like to be sure that many different aspects have been considered and that we have not missed any important factors in the Decision Process. For any decision, the most important point is to be sure that we have not overlooked any possible solutions to the problem.

A prototype Mission Area Analysis model will be created which will represent the different tasks that the Spanish Air Force could face in different scenarios. Each branch will have a weight determined which will define its relative importance. At the end of each branch there will be a utility value representing the capability of the Spanish Air Force in the fulfillment of that specific task.

The specific techniques upon which this thesis is based are:

1. Decision Analysis.
2. Multiple Objectives Decision Making.
3. Mission Area Analysis.

each of which is discussed further in chapter II.

Application of theory to the real world is often not easy. Still, theory is a very important part of the solution, because it gives the best understanding of the problem. In this thesis will be established a new theoretic planning model, and its real implementation could be difficult at the beginning. The practice and understanding of the model for each person who deals with the model could make easier the whole process, and its implementation.

Activating the model several times, and changing the different weight values, will represent the different strategies that can be followed for a country. Similarly, changing the utility values allow us to figure out which is the best selection from different weapon systems to solve a specific threat.

Initially, the political level has to define, for the different threats, which will be the most dangerous or the most probable, and the risk level that they are ready to deal with or could be faced with, politically. This means that we must work with an uncertain process, and it makes this partitioning as well as the next one, very important in obtaining an adequate set of conclusions.

The application of the process will give us the parameters of our support to the decision maker because it will allow us to recognize the boundaries as well as the solution, and to estimate the margin of error that we can tolerate.

For instance, it will allow us to decide, based up on a certain set of means, the future maximum level of risk that we could support, in terms of probabilities of each threat. Also, we could assess the acquisition of a new weapon system to replace an old one, maintaining a similar operational level or, increasing it. The former case will be used in this thesis.

The model developed in this work is similar to that used by the USAF, and could be extended to fit other Allied Air Force planning processes, considering their peculiarities. Also it could be useful for other military services, or departments, in their respective decision processes.

II. Literature Review

2.1 Introduction

The following paragraphs review literature pertinent to this research proposal. Specifically, the discussion covers the United States Air Force (USAF) Planning System, North Atlantic Treaty Organization (NATO) Planning System, and Spanish Air Force (SAF) Planning System. The summary is a review of the most important points of each Planning System.

As was established before, in the introduction to the problem, every day it is becoming more difficult to make decisions, because the events in the world and the technological levels change so very quickly. The decision maker must incorporate changes in many factors for each decision in a very short period.

In the military, before making any decision, it is necessary to think about and be confident of, the supporting analyses, because the output will often be measured in human lives.

2.1.1 A new planning system. Until nowadays, when any Air Force felt that a weapon system was obsolete, they studied the potential market, or they built up a system that fulfilled their requirements. However, it is becoming more and more difficult, due to both high prices and technological levels. In fact, today many of the Air Forces around the world can get all or almost all its means through its own national defense industry.

Every year countries are reducing their Defense expenditures. This means that the Air Force has fewer available resources. Also the Army and Navy have a significant air power capability and can carry out their own air missions. Sometimes it is very difficult to define the line between the Air Force's and the other services's missions. These factors make it very difficult to not duplicate the effort applied against the same objectives from different sources of air power, thereby wasting resources.

This new planning system looks for a clear definition of the different tasks for the Air Force, and consequently to use those definitions to determine the means that are needed. Also, it defines a force mission structure and permits the civil authorities to better know the Air Force's capabilities and perceptions of its missions.

2.1.2 Aims. A lot of diverse factors, such as the increasing scarcity of natural resources, the huge prices of the systems being built, public opinion, operational aspects, and so on, are included in the decision to buy a new weapon system. As Quade indicated, "Defense decisions now depend heavily on systems analysis" (16:6).

It is necessary to define a system which can help the decision makers do their work more efficiently and more easily. One aim of this thesis is to help the Spanish Air Force decision makers. An important part of defining a new system is to review other similar systems and then choose the best parts of each system that can be applicable to the particular case. Lt. Gen. Thomas R. Ferguson stated:

> "As the decision makers change, so changes the perception of the requirement, the threat, and other factors as well, resulting in frequent modifications in funding, schedule, and requirements." (6:5)

Another of the aims of this thesis is to establish a tool, or system, which provides a framework to ensure consistency of decision maker's, and which is able to detect changing perceptions and situations.

2.2 Discussion

The review will be based on systems already tested, like the USAF and NATO systems, and an overview of the current Spanish system.

2.2.1 The United States Air Force (USAF). Among the tools used by the USAF is Mission Area Analysis (MAA), which begins by making an assessment of requirements and performance capabilities. This appraisal could be reviewed for a change in any of the following factors:

1. Deficiency in an existing system
2. Technological opportunity
3. Threat
4. Opportunity to reduce costs
5. New defense interest

When a shortfall is detected in any one of these fields, it is included in a Program Objective Memorandum (POM), which is active for the next five years, and is submitted by the Chief of Air Force Staff to the Department of Defense (DoD).

Once the DOD initially approves an acquisition program, then the USAF (i.e., Air Force Systems Command) follows a process of looking for a new weapons system which will cover all the requirements. If the weapon system already exists in the national or foreign market, then the system is bought; otherwise, it is developed within current or new technologies (1). The last kind of process is the most used, which means that the USAF, for various reasons, (mainly Economic, Technological, or Political) does not usually buy foreign weapon systems.

As the United States (US) has the technological leadership, the USAF requirements are mainly satisfied by national contractors. The United States can develop the new weapon systems for the USAF necessities and for the requirements of other countries. It means that a new weapon system, developed for the USAF, frequently fills both the USAF and other foreign Air Forces' requirements.

In Appendix A is a diagram of the development planning process and the requirements, with the milestones as follows:

1. Milestone 0: Concept definition of the weapon system from the Statement of Operational Need (SON). This Milestone includes the creation and experimentation (call EXP phase) of the model.
2. Milestone I: Demonstration and Validation (DEM-VAL).
3. Milestone II: Full Scale Development (FSD).
4. Milestone III: Production.
5. Milestone IV: Based on the modification of an existing weapon system.

The process is much more complicated than it looks in this short summary, but for the purpose of this thesis it is only necessary to get an overview of this process.

Summarizing, the USAF planning system defines their requirements at medium and long range, and the national industries follow a process that ends with the development of a weapon system, which fit the specified requirements, because the USAF tracks the process with the constant aim of reaching the MAA goals. From this system can be learned the great importance of a Mission Area Analysis.

In an operational sense, the USAF describes the specific elements of these actions in its missions and specialized tasks, in its Basic Aerospace Doctrine.(4)

2.2.2 North Atlantic Treaty Organization (NATO). Since NATO is an organization and not an actual country, it does not have the same problems as its members when planning. In fact, there is a big difference, because each country defines its own requirements and which of its own assets will contribute to the Common Defense (NATO).

NATO defense military planning (Appendix B), has two processes, biennial and annual. The biennial cycle (Five year plan) begins with the Ministerial Guidance (MG) elaborated by the Defense Planning Committee (DPC), and defines NATO's goals and policy. Based in the MG, the Major NATO Commanders (MNCs) set up their Force Proposals (FP) for the period. These proposals are submitted to the

Military Committee (MC), where the Defense Review Committee (DRC) study and discuss them, and will be compared with each country's responses to the Defense Planning Questionnaire (DPQ). After this analysis NATO will define its Force Goals (FG) for the next five years. Every Ministerial Guidance (MG) will produce two DPQ responses, and two revisions of the NATO Force Plan(10:102).

Yearly (Annual process. Appendix B), all the countries give a response to the NATO's Defense Planning Questionnaire (DPQ), which is a basic document in the NATO planning system. In this document every country gives NATO all the information about different subjects on their forces, as well as the forces that they will provide for the Common Defense. This document (DPQ), brings to NATO all the information that it needs for its planning system; it is a firm commitment for the first year and a forecast for the rest of the period (10:112).

> NATO's force planning procedures are thus the machinery for determining the forces required for the defense of the Alliance, coordinating national Spain plans, and drawing them towards the agreed Force Goals in the best interest of the Alliance as a whole, while also monitoring countries actions in respect of the recommendations of studies some of which may be undertaken independently of the procedures but can be introduced into the process at an appropriate stage when ready for implementation(12:149).

NATO and Spain have a special agreement, and according to it, Spain presents its Force Proposals (SPFP) simultaneously with the MNC's, and receive from NATO its Spanish Force Goals (SPFG) from these NATO Force Goals (Appendix C).

The organization's higher authorities can elaborate on plans with the assets that each country member will decide freely, in advance, to put under NATO control. Each country makes plans with its own assets, and NATO works with the member country's forces. The most important part of the NATO process is the way in which NATO identifies its capabilities, shortfalls, requirements and a system of assigning priorities.

NATO breaks down the main mission into different Components, which are tasks within the general mission and they are essential to the attainment of its objectives (14). For the achievement of each of these Components, it is necessary to develop some military conditions, activities or operations, which could be called "Functions"(15:).

It is done in a such way, because it is a good pattern to check that all the possible aspects of the problem are considered and it also makes it easy because it reduces the size of the problem. This method is very similar to the Mission Area Analysis (MAA) pattern used by the USAF.

Once a Mission is defined, it can be decomposed by deducing the required components for each mission. By looking at each of these components, it could be determined which functions should be included and the assets necessary for it. Depending on the importance of each component and function, a list of shortfalls and priorities could be obtained. NATO, based on these priorities and shortfalls, can assess the threat that each can generate, and the associated risk.

In summary, it is interesting t note how NATO looks mainly at the operative planning level, considering the differe cenarios in which it can be involved in war. NATO puts a strong emphasis on looking at the mission, and breaking it down in sub-factors or functions that can easily afford a total fulfillment of the goals.

2.2.3 Spanish Air Force (SAF). In 1986 a new planning system was defined in Spain. It was a consequence of the new structure of the Spanish Department of Defense (5:17-19). In Appendix D are the new structure, and the current Spanish planning system.

Up until 1986, the Spanish Air Force (SAF) was actually a specific and independent logistic and operational command. Today, the Spanish Air Force is more a logistic command which prepares the force for the operational commands (Unified or Specified). The operational commands will be created in war, meanwhile, the SAF trains and maintains forces ready for combat. In Appendix E the basic Air Force structure is depicted. After the integration of Spain to NATO, the SAF also faced a challenge regarding its doctrine, tactics, and planning system (8:558). Thus far, when any one of the SAF components had a need, they submitted a request to the Air Force Staff, which after processing, proposed to the Chief of the Air Force Staff (CAFS) the acquisition or update of any weapon system.

Once the CAFS decided to buy or update the system, he names one Program Director who, with Air Force Staff advice, proposes a team consisting of experts, technical persons, and staff personnel. This team began to work, following a set of guidelines used before in similar kind of tasks, as well as the orders from the director of the program.

The Program Director, after the initial studies, presents to the CAFS an initial pre-selection of the different alternatives which could accomplish the specified requirements for a new weapon system. When the CAFS approves the initial selection, then the team begins to deeply study the different alternatives, and they give a final assessment as input to the final decision of the CAFS and Secretary of Defense.

It may be possible to improve this process using Operations Research techniques to help the decision-maker in his final resolution. Other factors, such as international policies or the needed support to the national industries, can disturb the process in an unexpected way from the analyst's point of view, they may not easily be taken into consideration here.

The Spanish aeronautical industry is currently manufacturing several types of aircraft, such as training, light and medium transport. This can be an important factor to be considered but, sometimes, the Spanish Air Force has to look at the foreign markets for the acquisition of weapon systems with the very latest technologies. It is an important factor to be considered in the planning system, for the appropriate level, because sometimes could be useful for the country and for the Air Force to invest in Research and Development helping the national industry.

2.3 Techniques.

Although different operations research methods will be discussed in the thesis, and the importance and characteristics of each will be pointed out, it is useful to introduce the techniques that will be applied.

2.3.1 Decision Analysis. The first technique that will be useful is the Structuring of Objectives and the Tradeoffs under Certainty, which is described very well by Keeney and Raiffa using lotteries and certainty monetary equivalent (CME) methods.(18:31-131).

Decision Analysis specifies the alternatives, information, and preferences of the decision-maker and then finds the logically implied decision. Since uncertainty is at the heart of most significant decision problems, decision-making requires specifying the amount of uncertainty that exist given available information. The application of decision analysis often takes the form of an iterative procedure called the Decision Analysis Cycle(9:8). The procedure is divided in three different phases: Deterministic, Probabilistic, and Informational.

In the deterministic phase, the variables affecting the decision are defined and related, values are assigned, and the importance of the variables is measured without any consideration of uncertainty. The second phase introduces probability and decision-maker attitudes towards risk (averse, neutral, or prone). Finally, the informational phase reviews the results of the other phases, in order to eliminate the uncertainty of the important variables. The cycle is repeated until no more information is available or a final decision is taken.

With this procedure we can always assign a utility value for any activity. It means that when the decision-maker decides among the different lotteries that we will offer him, it will give us enough information to rank and assign utilities to the different activities or Air Force tasks over which our decision maker has authority.

2.3.2 Mission Area Analysis. Another useful technique is to break down the system, using a multi-attribute utility model methodology. It will use the idea of Mission Area Analysis (MAA), which essentially is a form of a linear weighted sum of value functions, which is in turn an example of a Multi-Attribute model.

For instance, the methodology employed in the reconnaissance/surveillance Mission Area Analysis is:

> "A multi-attribute utility model is hierarchical in nature, starting with the specified top-level factor for which an overall evaluation is desired. This factor is successively decomposed into sub-factors. In descending levels of the hierarchy such that each successive level is more specific than the one preceding. At the lowest level of the hierarchy are predictable or observable technical (or other) characteristics of the system under evaluation. The lowest level, highly specific characteristics are typically system parameters."(2:2)

This technique implies that we have to start with the main Air Force Mission, and then break it down through a hierarchical process. Following this pattern we will define a decision tree, with the main mission on the top of it, and each branch of this tree will represent each one of the different tasks that the Air Force can carry out.

2.3.3 Multiple Objectives Decision Making. This is another important technique that will be used in this thesis. Frequently it is necessary to use decision criteria based in multiple sub-objective analysis, which usually are considered under an uncertainty level. In this case, we have to define a Value Function (VF), which is a generalization of the utility function, and represents revealed preference information. There are two different kind of functions, additive and multiplicative. Value function are scaled from 0 to 1.(17:282)

The additive value function is represented for the summation of the products of the different attribute values (Y) by weight values (W). It can be written as VF=$\sum_{i=1}^{n} W_i Y_i$.

The multiplicative value function is the same as the additive with the corresponding interaction terms. This kind of function, produces the same ranking of outcomes as an additive form because the multiplicative model can be transformed into an additive function by taking logarithms.

We propose the use of an additive value function, because it is more intuitve. The only requirement in this case is that a preferential independence among attributes is required. The preferential independence between two different attributes with respect to a third attribute exists when the value trade off between the two first attributes is not affected by the level of the third attribute.

There are five basic steps in value function measurement, and they are as follows:

1. Familiarize the Decision Maker to the concepts and techniques of value function measurement.
2. Identify the appropriat value decomposition form (We propose additive form).
3. Measure component value functions (Y), or attribute values.
4. Determine the different weight values (W).
5. Validate the consistency of the Y values against Decision Maker observed ranking.

For our purpose, each Command should define its own additive value function for the new weapon system. They have to define the attributes that are important in each case, as well as the different weight value for each one. The different attributes must be preferentially independent.

2.4 Conclusion

It will be possible to define, in the next chapter, a process for the Spanish Air Force which will be demonstrated in this thesis and will have the following characteristics:

1. It will use the basis and the particularities of the Spanish system, because this system must integrate into the Spanish Defense Planning structure.
2. It will choose the best characteristics of each system with the purpose of optimizing the result.
3. It will be in agreement with the Spanish commitment with the NATO.

Finally, once the appropriate system for the Spanish Air Force has been defined, it will be possilbe, through adequate sensitivity analysis, to determine how robust the answer is. This will be done with an example in Chapter IV, comparing two different weapon systems.

III. The Structure of the Problem

3.1 Introduction

In this chapter it is necessary to define the structure model, which will be used in the rest of this thesis. The model has to reflect the particular geostrategic position of Spain and its National structure and treaties.

3.2 Discussion

From the research (Chapter II) the importance of the scenario in the planning process can be deduced. Once we know the scenarios, the main concern should be to structure the model to reflect those scenarios. For this analysis, it will be appropriate to break it down using concepts of the already explained Mission Area Analysis (MAA), Components, and Functions.

In the Spanish case different basic factors which define particularities of the Spanish situation must be considered. The first steps will be to define the main factors that could define the scenario in which the Spanish Air Force has to carry out its missions. Later, it will be necessary to define the Components and Functions for those missions. These factors could be defined in different ways than are used in this example.

Five main factors will be considered in this thesis, corresponding to:

1. Geostrategic position (Level 1)
2. Alliances (Level 2)
3. Intensity of the conflict (Level 3)
4. Components (Level 4)
5. Functions (Level 5)

Each of this main factors will define a specific "level" in a decision tree, which will represent the different situations in which the Spanish Air Force could be involved. Each level has different characteristics. For example, the first level is a consequence of its geographical situation and historical relations; the second and third levels depend on the current political situation and agreements. Finally the two last levels are clearly military, where the fourth can take into consideration the other services while the last one is only a matter of the Air Force. This means that the Air Force levels (four and five) have to be built up considering the important factors such as the scenario, political strength, as well as the role of the other services.

Each level has many components defined for this thesis, and they would be different for each country, and, of course, for each service. Every node of one level may have under it a full additional level of components. Part of such a tree is shown in Appendix F (some of the nodes are not fully expanded).

The data required for this form of analysis includes weights on the branches and values at the ends of each branch. The appropriate agencies for determining these data are identified later in the thesis.

A short summary for each of the five levels follows.

3.2.1 Level 1. Due to the Spanish geostrategic position, and Political relationships, there are three different kinds of threats against the national integrity and sovereignty(7:45-65). These are the threat from the (Appendix G)·

EAST: Corresponds to the Soviet forces, with or without the support of Warsaw Pact forces, should they try to get control of the Straits of Gibraltar. This action could furnish to the Soviet forces an advantageous situation with respect to the south flank of NATO and also of the Mediterranean Sea, with the corresponding implications, with respect to the control of Middle East and oil production areas.

Spain also could be involved in a conflict from this region as a result of Western policy or as a result of Spain's historical relationships with the Arab countries of the North of Africa (Libya, Algeria, Tunisia or Morocco).

WEST: In an East-West conflict in the European scenario, the reinforcement of Europe through the Atlantic could be vital for the Western forces (NATO). One of the first actions of the Warsaw Pact may be to cut off the reinforcement of European forces from the United States of America through Great Britain and Spain, which implies a threat for Spain from the Atlantic (West). In this task, Spanish forces should work within the NATO structure.

SOUTH: The North-Western African region, traditionally called "Magreb" has long been a conflict area due to colonialist claims against European countries (mainly Spain and France). Some North African countries maintain a claim against the Spanish lands in the North of Africa and the Canary Islands, as they did some years ago against the Sahara (then a Spanish colony). Depending on the internal and political stability of these African countries, Spain may be threatened when they try to avoid their particular or internal problems by focusing their attention on any of the Spanish territories.

This threat also could be supported by the Soviet Union when trying to disturb or collapse the south flank of Europe (We could also say NATO) subverting the Region through some Arab countries (Libya, for instance).

3.2.2 Level 2. Spain can face each of the three mentioned threats (Level 1), in two different ways depending upon the kind of threat, and his alliances. We will consider the two cases as follows (Appendix H):

NATO COMBINED If the aggression against the Spanish interest is considered inside the Agreement between Spain and NATO, then the Spanish forces would fight, integrated with NATO forces, against the threat.

NATIONAL: This could be the unlikely case of a conflict create by Spain or out of the NATO framework. This level could be explored in a more detailed way, but much has been written about Spain and NATO Agreements, in fact currently some of these Agreements are in their implementation phase, and a complete exploration is beyond the scope of this work.

3.2.3 Level 3. Represents the different intensity levels of conventional conflicts that could break in these scenarios. Nuclear war could be considered as a part of this branch of the tree, but it is more convenient to consider it as different problem because its requirements are so different from those of conventional conflicts. In this thesis we won't mention nuclear conflicts for two reasons:

1. Because Spain does not has nuclear weapons.
2. For a nuclear conflict, we have to define a decision tree, similar to a conventional one, but not related to it.

There are three different classes of conventional conflicts, where force has to be available for deterring or fighting: crisis, low intensity, and war (Appendix I).

The different classes of conflict could be defined in terms of the amount of the force engaged in the conflict (represented in Appendix J). We will define the three kind of conflicts as follows:

CRISIS: This phase could be defined as : Military actions and procedures to demonstrate the capability of a country for defending its territory and favorably resolving a conflict, or deterring the enemy from an aggression. It is almost an unavoidable previous step before the war begins, where deterrence plays a very important role (One example could be the Persian Gulf events for the allied forces, before January 15 1991).

LOW INTENSITY CONFLICT: This is defined as: A limited politico-military struggle to achieve political, social, economic, or psychological objectives. It is often protracted and ranges from diplomatic, economic, and psychosocial pressures through terrorism and insurgency. Low-intensity Conflict is generally confined to a geographic area and is often characterized by constraints on the weaponry, tactics, and the level of violence.(11)

This level requires a moderate effort for the armed forces, but if this kind of conflict stretches too long, it could be very expensive (in every way) to maintain it. Guerrilla wars are a typical example of this kind of conflict.

TOTAL WAR: This means that a country is involved in the fight against the enemy, also called general war, and is defined as: Armed conflict between major powers in which the total resources of the belligerent are employed, and the national survival of a major belligerent is in jeopardy.(11)

3.2.4 Level 4. The two last levels of the analytical breakdown could be considered as the Mission Area Analysis for the USAF or as components and functions, as NATO does. In this level it will be necessary to consider those main Air Force Operations that could be carried out by the Air Force in an independent way, meaning that accomplishing one of them does not necessarily imply accomplishing the others. For instance, the Air Superiority reached through the Air Battle is necessary to a successful participation of the Air Force in the Surface Battle, but some Air-Ground Operations in support of the Army could be carried out without a proper Air Superiority.

The components considered here are defined as follows (see Appendix K):

CONTROL OF CRISIS (C. CRISIS): All military actions conducted to demonstrate the country's abilities, with the intention of deterring any aggression and defending their own territory(15). (Adapted from NATO AAP-6)

AIR BATTLE (AIR BAT.): Military actions to minimize the impact of the enemy's air power attack on the country, forces and operations and enable to our own land, sea and air forces to conduct operations at a given time and place without prohibitive interface from the enemy's air forces(15). (Adapted from Nato AAP-6)

SURFACE BATTLE (SURF. BAT.): The destruction or neutralization of land or navy enemy surface combatants, support, or auxiliary forces by our air power(15). (Adapted from Nato AAP-6)

INTERDICTION (INTER.): An action to divert, disrupt, delay or destroy the enemy's surface military potential before it can be used effectively against friendly forces. (JCS Pub.1)

COUNTEROFFENSIVE (C. OFFEN.): A large scale offensive undertaken by a defending force to seize the initiative from the attacking force. (JCS Pub.1)

AIRLIFT (AIRLIFT): The performance or procurement of air transportation and services incid‹ . ˏ thereto required for the movement of persons, cargo, mail, or other goods. (JCS Pub.1)

SPECIAL OPERATIONS (S. OPER.): Operations conducted by specially trained, equipped, and organized DoD forces against strategic or tactical targets in pursuit of national military, political, economic, or psychological objectives. These operations may be conducted during periods of peace or hostilities. They may support conventional operations, or they may be prosecuted independently when the use of conventional forces is either inappropriate or unfeasible. (JCS Pub. 1)

All these missions are generally conducted in a joint way, because the results affect or include every service. The notation inside the brackets will be the notation used for each action in the tables.

3.2.5 Level 5. This last level contains the different Air Actions or Operations, necessary to independently fulfill every one of the components defined in level

4 (Appendix L). These activities, depending of their nature, could be called anything from actions to operations. They can be carried out independently or jointly with other services. Some may important to one component of the fourth level but unimportant to another component. These activities are clearly a matter of the Air Force.

These actions, defined in Appendix M,are the following(15).(3):

1. COMBAT READINESS (CR).
2. AIR DEFENSE (AD).
3. AIR OFFENSE (AO).
4. AIR INTERDICTION (AI).
5. TACTICAL AIR SUPPORT MARITIME OPERATIONS (TAS).
6. CLOSE AIR SUPPORT (CAS).
7. ANTI-SUBMARINE WARFARE (ASW).
8. AIRLIFT (AL).
9. SPECIAL OPERATIONS (SO).
10. SEARCH AND RESCUE (SAR).
11. BASES DEFENSE (BD).
12. ELECTRONIC WARFARE (EW).
13. SUPPRESSION ENEMY AIR DEFENSE (SEAD).
14. COMMAND CONTROL AND INTELLIGENCE (C2I).

The notation inside the brackets will be the notation used in the tables.

3.3 Discussion

Once the structure of the problem has been defined, it is necessary to assign responsibilities for each level and take a look at its use. The data for the two first levels have to be defined at the highest political level, because they are a consequence of the national policy. The data for the third level is in the domain of the National Security Council; i.e., the highest military authorities. Finally, the two last levels are clearly a military responsibility, where the fourth level has a joint character and the fifth level is strictly a matter for the Air Force.

The problem could be studied looking at it from two different perspectives: from the top to the bottom or from the bottom to the top. Each approach supports a possible application of the problem. The first one could be useful for defining a Force Structure and the second one for study of Force Employment or substitution of a weapon system.

1. FORCE STRUCTURE: Beginning at the top of the tree, the political level decides which commitment they want to reach and then the bottom level should define what Force Structure is necessary to support those commitments.
2. FORCE EMPLOYMENT: Starting with the actual and current status of forces, the military authorities could offer advice at the political level about:
   (a) The capabilities of the Armed Forces for facing the different kind of conflicts.
   (b) Initiating the planning process for the substitution, looking at medium or long term, of weapon systems which will be obsolete in the future.

This thesis focuses on the use in force employment because there are fewer political implications.

This model could be employed for the different services using their own mission, components, and functions. Equally, it could be employed in a Joint way, trying to save costs and share efforts among services. Sometimes two different services carry out the same task with the same or similar aims, so they duplicate effort in an effort to acheive the same result. For example a TASMO, CAS, ASW, SO, or SAR operation against the same target could be accomplished by forces of the different services. In these cases the Armed Forces do not perform efficiently, because in some way they expend a duplicate effort or spend money with the same goal. In the future it will be necessary to be very careful about how and on what to spend the budget. Thus, a Joint solution will be necessary. This model could be employed in a Joint way by adding an extra level between the fourth and fifth levels, where Joint Operations could be considered. This could be an interesting extension of the model, but it is beyond of the scope of this thesis.

3.4 Conclusion

In this chapter, a new planning process has been established. This new system has distinct advantages over the current system used in the Spanish Air Force. Some of these are as follows:

1. It defines a path to be followed, based on some concepts such as the Geostrategical position of the country and its political compromises. It does not depend on the variable criteria of the different authorities, or on a temporary situation.
2. The process could be used in a joint form, avoiding a possible repetition of effort on the part of the different services, for the accomplishment of the same mission.
3. It is based in a general context of the different missions of the Air Force, and not on only a restricted way or Air Command. It could be the case of the acquisition of a new weapon system for the Air Defense or the Airlift Command, without regard to the implications for other Commands.

4. This process is compatible for different planning systems, because it can be useful for the National Process as well as for the NATO process.
5. The defined path could be useful, with some changes, for different Services, as well as for different countries, looking toward their own particularities.

Now that the system for the Air Force has been defined, it is possible to make some general remarks.

The system is flexible because it can be used in various scenarios (countries), and for the different services. The system must set up all the possible missions, operations, or actions in which a force can be involved.

It is necessary to define all the different weights for the different branches of the decision tree, with criteria based upon the importance of each branch for the node on which it depends. For instance, for the Air Battle for the fourth level, there exists a complete set of branches depending on it. Some of these branches are very important actions for the Air Battle (Combat readiness, Air defense, Air Offense.) and they will have a high weight. On the other hand, some fifth level activities will have very low importance for the Air Battle (Close Air Support, Tactical Air Support,...), and they will have a very low weight.

Having defined all the weights, it will be necessary to provide utilities for the various options. Each branch has a utility value for each option, defined by the Air Force, and based upon their capability to carry out this mission, operation, or activity. These utilities must measure both the performance of the aircraft as well as the supporting infrastructure. For instance, if a number of air bases do not have an appropriate system of defense, based on missiles, bunkers, and so on, then the utility value for the airplanes will be very low for certain missions. On the other hand, if an Air Force has good radar coverage, Airborne Warning System, Intelligence System, and so on, then the same airplanes will have high utility values. These utility values will be numbers between zero (0) and one (1).

Finally, although the values of the probabilities and utilities will always be subjective, knowing and expressing them is the best way to self-evaluate and improve the Air Force.

IV. Methodology

4.1 Introduction

Once the total structure of the decision tree have been defined, it is necessary to identify the authorities that have to take on the task of assigning the values or corresponding weight at each branch. We also have to determine how to define the utility values in the bottom of each branch.

After defining the different responsibilities for providing data over the decision tree, it will be necessary, for the purposes of this demonstration, to make subjective estimates of all the values, and demonstrate the results. Sensitivity analysis will also be demonstrated, to show how the result can vary under certain changes or variations on some values of weights.

4.2 Discussion

4.2.1 Decision Sources. The two first levels are defined by the geographical, historical, and political factors. This means that, for Spain, the different branches (alternatives) and weights for the first and second levels must be defined by the highest authorities of the country, which form the National Security Council (similar to the National Security Council (NSC) for the U.S.). The weights (or probabilities), should be specified in the National Defense Directive (NDD), the basic document in the Spanish planning process.

The first level is defined based mainly on the geographical and historical assessment. The second level is more a political problem, but always with some other complications, such as economic, religious, etc.

The third level is a purely political decision, because there are political authorities who have to define the kinds and levels of risk that they are able to accept. This means that they must decide when a crisis could be resolved as a crisis, when it should end in a low level conflict, or in a war. Of course, since these decisions depend strongly on the military power of the country, they have to be assessed suitably by the military authorities.

The fourth and fifth levels are clearly military levels. Due to the nature of the fourth level, in which forces of more than one service can be involved, or could be affected by the different kind of actions, it can be said that the fourth level's weights are a Joint Chief of Staff's responsibility. It means that the Joint Staff has to study and assess which are the most probable actions in each scenario, in a balanced, objective, and efficient way. Finally, the fifth level is the Air Force's decision, as the Air Force is the technical expert in that regime.

4.2.2 Political Assessment. Because military decisions are based on the scenario defined for the political level, it is necessary that the political level defines the strategic arena. This is done, basically, by defining initially the appropriate weight values, through the documents which constitute the planning process.

Then given the different weight values, or assessment of the situation, the military authorities can define the next level's weight values. At the end of the process the political level will receive the appropriate feedback from the military levels. This will allow the political authorities to maintain or redefinc its weight values, in order to optimize the analytical process.

4.2.3 Defense Assessment. Once that the Department of Defense knows the weight values, defined for the political level, then they can provide advice, in the first stages of the analysis, concerning the weight values for the third level, and continue the process in both joint and specified ways.

When a final study about the capabilities of the Armed Forces has been done, as result of the obtained utility values, then the results have to be submitted to the political level. It will provide a valuable and appropriate feedback for the political level, in order that the political level better knows how the military will support political policies.

4.2.4 Air Force Assessment. Within the Department of Defense, the Air Force as well as the other services will do their assessments. We will define who, and how these assessments will be done, by describing the coordination and the calibration of the process. This will be done by different expert teams which the planning process defines. Now let us see how the Air Force could determine the appropriate values using a team concept.

4.2.4.1 Expert Team. The Air Force not only has to give the different weights for each fifth level's branches but it also has to calculate the utility values for each branch. These utility values represent the capability of the Air Force to accomplish its task in each of the different scenarios and missions (or components). These utility values are subjective, but homogeneous, because the assessments are to be done by the same Air Force Expert Team (AFET). These teams, will be integrated by different Air Force Expert Sub-teams (AFES) if necessary, working under guidelines given by the political and defense levels. The number and size of different AFES, will be determined by the AFET.

We have to define the characteristics of each kind of team, which are as follows:

AFET. The Air Force Expert Team (AFET) will be integrated in the Air Force Staff (Planning Division), and will be composed of between 8 and 12 people. They, in turn, will define in each case the appropriate number of AFES. AFET will coordinate, filter, and calibrate the assessments received from the sub-teams, also will determine which sub-team will be the most important (lead) team. The AFET team will maintain the appropriate coordination with the defense level, in order to get the information that Air Force will need, as well as coordinating with other services.

AFES. The Air Force Expert Sub-teams (AFES) will be integrated in the different Air Force Commands, and they will be activated as needed. They will be composed between 5 and 8 people. They will form, as needed, appropriate advisor teams or sub-teams, that will address specific concerns. These advisor teams or sub-teams will be composed of no more than 5 people, from the different units of the Air Force Command.

Among the different AFES, one of them, will be named the lead team. It will be the one most directly connected with the new weapon systems being addressed. It will coordinate and direct the work of the other sub-teams.

For instance, a team could be created for the study of a new fighter, and this team could consist of several sub-teams. One sub-team could study the air offense capabilities, another the air defense or electronic capabilities, and so on. Of these, perhaps the air defense sub-team would also be identified as the lead team.

4.2.4.2 Team Constitution. Each of these Teams (AFET) and sub-teams (AFES) should be built up, in each case, with the appropriate personnel (Pilots, Analysts, Engineers, Mechanics, Specialist Staff personnel, and so on), depending on the specific field of the Team or Sub-team. All the members of these sub-teams should be conscious of the weight values for the different upper level branches of the decision tree, for a more objective assessment. Henceforth, "team" will be used to refer to both teams or sub-teams, because the only difference is the size of the group, and where they are integrated into the Air Force structure. The term "expert team" (ET) will refer in general to any kind of expert team. Normally, some of the components of each AFES will be also an advisor or component of other sub-teams, as well as could happen with the AFET members. This means that the system is more a network, than a series of independent cells (Appendix N).

4.2.4.3 Team Assessment. The best way for team assessment is that each one define an additive value objective function, for their purpose. For an efficient assessment we have to define some attributes, for a determined weapon system, in order to compare and evaluate the different systems. These attributes have to be preferentially independent, otherwise the value function would be multiplicative, instead additive (19:119).

For a fighter, for instance, we should define attributes such as climbing rate, weapons, and electronic capabilities, which do not have to be directly related between them. In this case, the attributes are preferentially independent, and the objective function will be additive. In these kinds of objective functions, we can easily weight the different attributes if we want to do so. Once the teams get their value functions, they should scale the result to be between zero (0) and one (1).

Another means by which to perform the team assessment would be a step-by-step procedure (13:383). This consists of a practical process of measuring utilities in five distinct steps. The main procedure used in this case is based on different lotteries and certainty equivalents that we have to present to experts or decision makers, in order to get enough information to measure the different utilities.

This practical process consist of the following steps:

1. Define what is we want to measure – its nature, range and scale.
2. Setting Context. We must develop a way to present the interview to the person whose utility we are measuring.
3. Assessment using the certainty equivalent and lottery equivalent/probability methods.
4. Interpretation
5. Functional Approximation fitting an analytic function to the measurements.

We can suppose that each team will define an additive objective function, it means that each team will have to break down its Main Mission, or make a Mission Area Analysis (MAA) into different factors with different weights. Each factor will be an objective function; and in a perfect world they could be preferentially independents, but normally they won't be.

For instance, a team for the analysis of a new fighter could have a sub-team which studies the Air Defense aspect of the fighter. Other sub-teams could study the Air Offensive, or Interdiction aspects. Going on with the Air Defense case, they could establish different objective functions like: Combat effectiveness (such as force ratio and sortie generation capability), or Weapons, or Maintenance, and so on. The budgetary constraints are known, so they can assess the number of aircraft that they could buy. Therefore, every sub-team could establish an assessment, or utility, for each value function by studying advantages, and shortfalls, or deficiencies, for each candidate. We can suppose that the team assessment is based on different lotteries presented to the experts, or in certainty equivalent values.

Once it is determined who makes the different assessments, and when they are to be made, it is necessary to make some further considerations based on the two possible uses of the decision tree mentioned in Chapter III.

4.2.4.4 Team Coordination. All the values for the different levels should be defined for the appropriate authorities as part of the Defense Planning Process, and they should figure in the different process documents. They have to be a forecast on middle and long term provisions of the Defense (Political level) and military expected (or desired) capabilities. Some of these values have to be known by the Expert Teams (ET), whenever it could be related with their assessments.

It could be possible that a misunderstanding would develop between teams. For this reason, it is very important to maintain a good coordination between teams. The Air Force Staff will take over this task while depending on the main team or the team more directly related with the new weapon system to be the responsible for establishing and maintaining adequate coordination between teams at the same level.

Normally all or at least several Commands will be involved in the assignation of utility values. It means that the different Commands will have to create their own Expert Team for whatever weapon system we plan to buy.

For instance, if we plan to obtain a combat airplane, the Airlift Command must to set up its own team, in order to assign the utility values of this Command with respect to the Airlift capabilities needed to support the new airplane. This means that the Airlift team has to evaluate how the Airlift tasks will be changed by the new weapon system.

The method followed by the different teams, for the measurement of utilities, has to be on the same scale, in order to get an adequate homogeneity in the values. If this were not possible, once the AFET gets the assessed values from the different sub-teams, the AFET could use a *team commensurability technique.*

4.2.4.5 Team Commensurability Technique. When we receive different assessments from different Commands made using any of the Operation Research (O.R.) techniques before presented, it can be the case that two or more of the Commands use a different technique or scale. We then need to make the values commensurate, in order to be sure that the rules for combi.ιing the sets of values from different sources makes sense. We can use the following technique that we will then illustrate with an example.

Let us suppose that the event M_1, has two different possible decisions, one of them is the best (B_1), which has the highest value. The other decision is the worst (C_1), and has the lowest value. The same happens for the event M_2, where values B_2 and C_2, are respectively the utility values for the best and the worst decisions. Although the utility values are on different scales, they can be always standardized in between the values of one (1) and zero (0). We now form a combined scale, where the highest (in the subjective sense) value between B_1 and B_2 would be set to one (1), and the lowest value between C_1 and C_2 would be set to zero (0). The total range between the highest and lowest value will be one. The next question is how to place the yet undefined values on the combined scale. Both events are the possible outcome for a decision maker, and each one has a weight value as it is shown in Appendix N.

In our case, the events M_1 and M_2 will have two different utility values of two different Functions (For instance, Air Defense and Air Offense). The values B_1, and C_1 are the utility value for one Function obtained through two different procedures. Values B_2 and C_2, are for the other function. The values of the two weights (W_1 and W_2), are known because they already have been defined.

The analyst has to offer to the decision maker (D.M.) at this level, two lotteries, as they are in Appendix O. The D.M. has to be indifferent in two different lotteries between the possible outcomes for one event (B_1 and C_1, for instance), compared with the best (B_2), and the worst (C_2) outputs for the other event (Appendix O).

These two lotteries, will give a probability value for each one that we will call X and Y in this case. Using these values (X and Y), we will find corresponding values, W_1' and W_2'. Then we will check if these values have the same relationship that the assigned ones (W_1 and W_2). If the relative values of W_1 and W_2 match with the assigned values, this will mean that the values are well calibrated. This process acts as a validation for those values.

There are three kind of possible ranking of the outcomes (B_1, B_2, C_1, and C_2), they are represented in Appendix O and are as follows:

1. Case 1: The values of one event (B_2 and C_2, for instance), are between the values of the other event (B_1 and C_1). This means that the order of utility values from highest to lowest is: B_1, B_2, C_2, C_1.

2. Case 2: The B_1 and B_2 values are higher than C_1 and C_2 values, and they are ranking in the same order. It is the case for the order from highest to lowest utility value, could be as follows: B_1, B_2, C_1, C_2; or: B_2, B_1, C_2, C_1.

3. Case 3: The utility values for one event have a higher value than the highest value of the other event. This is the case in which the order from highest to lowest utility value could be as follows: B_1, C_1, B_2, C_2; or: B_2, C_2, B_1, C_1.

The lotteries for all cases are not the same, but the rule is to find the value of the probability X for the best outcome, and the probability $(1 - X)$ for the worst outcome, which makes the D.M. indifferent compared with the second highest ranking utility value for sure. When the D.M. is indifferent comparing the same values with the third highest ranking utility value, then we will get the value of Y. For this thesis purpose we can suppose that the addition of weights is one (W_1+W_2=1), because we want to known the relative relationship between the real W_1 and W_2. It means for instance, that for a set of values of W_1=.6666 and W_2=.3333, the real weight of the first Function (1), has to be the double than the weight for the other Function (2), because W_1 is twice the W_2 value.

In the first case, from Appendix O, we can see that the values are $W_2 = X - Y$, and $W_1 = 1$. Then normalizing the values we will obtain the following values:

$$W_1 = \frac{1}{(X-Y+1)} \qquad W_2 = \frac{(X-Y)}{(X-Y+1)} \qquad \text{(Case 1)} \tag{4.1}$$

In the second and third the value for one weight is equal to $(1 - Y)$, and for the other is equal to X. So the values are the same but with different subscripts. The values are as follows:

$$W_1 = \frac{(1-Y)}{(X-Y+1)} \qquad W_2 = \frac{X}{(X-Y+1)} \qquad \text{(Case 2)} \tag{4.2}$$

$$W_1 = \frac{X}{(X-Y+1)} \qquad W_2 = \frac{(1-Y)}{(X-Y+1)} \qquad \text{(Case 3)} \tag{4.3}$$

In conclusion, we always could commensurate the utility values and check that the relationship between two weights are corrects, based on the lotteries that we have proposed to the D.M., which in this case could be the Air Force Chief of Staff or his staff. In this way we also validate the weights and utilities of the model.

4.2.4.6 Team Calibration. A problem that could exist is a possible lack of coordination, and in consequence a disagreement between two different teams. This means that we need to calibrate, and filter the different Team assessment, and to ensure that the different coordination between levels has been maintained.

We can say that there are three different components of the Air Force that will participate in this process. These components are: The Air Force Headquarter represented by the Air Force Staff (AFET), the different Air Force Commands (AFES), and finally the expert team components (AFES) or elements of the different Air Force wings or units (Pilots, Engineers,..).

The last two will assign the utilities for the different weapon systems, and the Air Force Staff will be the filter and coordinator in the calibration process. Filtering will compare and will assess the different outputs from the other two Air Force components. Coordinating will maintain the appropriate flow of information with the other planning authorities that are responsible for the whole process. This will ensure that all parties have access to the weights and values being used in that process.

The Appendix P represents in a flow diagram the concept of filter that the Air Force Staff must carry out. The Air Force Staff has to coordinate with the Defense level in order to know the different weight values assigned in upper levels. The Air Force Staff will inform its subordinated levels, about the weight values, through the decision tree, that could be important for them in their assessments. The filter represented in Appendix P is part of the Air Force Staff responsibility, in that they must assess and calibrate the different values (weights and utilities) given to or received from its subordinates corresponding to the fourth and fifth levels of the decision tree. The values for the third level of the decision tree, also affect and must be assessed by the Air Force Staff, and they have to be sensible in the context of the other values given for the Air Force.

4.3 Considerations

The decision tree can be used in two different applications, as was said before, depending on the way that the user looks at it. Looking at the decision tree from the top to the bottom emphasizes the political considerations, while looking at it from the bottom up emphasizes the technical considerations.

Viewed from the top, the political level defines the role that they want to keep in their geostrategical area, then, at the bottom of the decision tree we will need certain utility values to support those roles. These utility values will define the force structure that the country will need for supporting the mentioned political role. This could be called "Force Structure", because it defines, at the bottom of the tree, the structure that is needed for supporting a determinate strategy or policy.

If the measure across the decision tree is from the bottom to the top, the utility values will define the current capabilities of the Air Force at that point in time. Going up, from the bottom to the top of the decision tree, it will end on the top with a value. This value will represent the Air Force capabilities, which could support the political decisions.

In some way, the last alternative gives the maximum range for political decisions and the associated risks. In other words, it could show when a political decision lacks of the necessary military support. This process could be called "Force Employment", because it gives to the political level a good idea about the military power that could support their policies or strategies. This will be a good feedback for the political level that has defined the weight values for the first three levels.

One of the reasons for using a decision tree, is because in this way, we deal with expected utility values (EUV)(17:86). When we compare two different missions, it is very difficult to be objective, and define the performances of the same or different weapon systems in both cases. The EUV, will give us the possibility of compare and deal with homogeneous values.

4.4 Weights and Utilities

At this point we will assume that good values have been made of the weights and utilities, for the corresponding levels of the decision tree.

4.4.1 Weights. The weights will take values between zero (0) and one (1), and the summation of all the weights for each level will be equal to one (1).

4.4.2 Utilities. The utilities will also have a value between zero (0) and one (1), and will represent the capability of the fulfillment of a specific task in a scenario. Zero (0) may mean no possible capability for a specific function, or that the function does not have any relation with the corresponding function. One (1) represents a full power to support the scenario component.

The following tables show the assumed values for all the weights and utilities, representing the current values for all the different levels for the Spanish Air Force. These values are nominal for this thesis's purpose.

4.4.3 Values. These values could define the current capabilities of the Spanish Air Force and the assessed capabilities of the proposed alternative force structures. The following Tables are an example of weights for the fourth and fifth levels (assessed by Military and Air Force authorities), and utilities values (assessed by the Air Force (AFET)). In this case, they represent the values facing an EAST threat, inside NATO, and for a Low Level Conflict, as it is shown in the table. The rest of the Tables are in Appendix Q for weights and in Appendix R for utilities. All the tables together will define that we will call: Spanish Air Force "Current Status". They show the different weights for the different branches, as well as the utilities of the Spanish Air Force today. The meaning of the different values that are expressed in the tables will be explained later.

Table 4.1. Current Status

CURRENT STATUS WEIGHTS														
	LEVEL 1: EAST			LEVEL 2: NATO				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.100)	.300	.100	0	0	0	0	0	.100	.100	050	0	.150	0	.200
AIR BAT. (.350)	.100	.250	.150	0	0	0	0	100	.025	.025	.100	.100	0	.150
SURF. BAT. (.200)	.150	0	0	0	.150	050	.150	.150	.100	.050	0	.100	0	.100
INTER. (.050)	.100	0	0	.250	0	0	0	.050	.050	.050	0	.200	.150	.150
C-OFFEN. (.100)	.150	0	.200	.050	.025	0	025	.050	.025	.025	0	.200	.150	.100
AIRLIFT (.150)	.100	.150	.025	.025	125	.025	.025	.200	.025	.025	.050	.100	.025	.100
S. OPER. (.050)	.200	.025	.025	.050	0	0	0	0	.200	.025	0	.200	.075	.200

Table 4.2. Current Status

CURRENT STATUS UTILITIES														
	LEVEL 1: EAST			LEVEL 2: NATO				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.90	0	0	0	0	0	.90	.90	.85	0	.80	0	.80
AIR BAT.	.85	.90	.85	0	0	0	0	.85	.85	.85	.70	.85	0	.80
SURF. BAT.	.75	0	0	0	.80	.60	.80	.85	.70	.75	0	.70	0	.70
INTER.	.70	0	0	.75	0	0	0	.60	.60	.60	0	.60	.50	.50
C-OFFEN.	.75	0	.70	.75	.80	0	80	.70	.70	.70	0	.75	.70	60
AIRLIFT	.90	.85	.70	.60	.70	60	80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.65	.60	.40	.20	0	0	0	0	70	40	0	.60	.50	.60

For the purpose of this thesis, we will suppose that the weight values for the three first levels have been defined by the appropriate authorities, and are as follows:

FIRST LEVEL:

WEST=.1 EAST=.4 SOUTH=.5

SECOND LEVEL:

In this level the weights for the different threats are not the same, because facing eastern or western threat are more in NATO likelihood, meanwhile a south threat could be confronted only by Spain. It means that in some way this level values, are related with the First Level values. In this case we will consider the weight values as follows:

NATIONAL=.650 NATO=.350

THIRD LEVEL:

The defined decision tree has 1764 different branches. It is too big for the purpose of this thesis and its demonstration. A reduction at this level will cut down the number of branches to one third, and then, we will have 588 branches. Thus, at this point we will consider only one kind of conflict in order to avoid a long list of values and appendices. This means that we will give a zero value to two of the branches (WAR and CRISIS).

We will suppose that the values given in the tables, have been assessed for the Expert Teams based on the fact of a Low Level Conflict, because these values will change depending upon the kind of conflict. It means that the utility values could change, as the intensity of the conflict changes. The demonstration of the problem and use of the decision tree will be the same, and we can equally evaluate the results.

Now we can consider that the whole decision tree has been define, and also we assume that the political circumstances and threats will remain constant in a short and medium term. It means that the decision tree when we compare the two new weapon systems, will remain the same.

4.4.4 Table explanation. In this section we will give an explanation of the Tables, indicating what represent each value. We will use the Tables above mentioned.

4.4.4.1 Weights Tables. The weight tables shows two different values. First, inside of each Component box is its corresponding weight at the fourth level. These values must sum to 1.0. The weights in each row, express the different function weights for each component. These weights must sum to one. For instance, in Table 4.1, for the function of Control of Crisis (C. Crisis) the weights are as follows:

Combat Readiness (CR)	.300
Air Defense (AD)	.100
Airlift (AL)	.100
Special Operations (SO)	.100
Search and Rescue (SAR)	.050
Electronic Warfare (EW)	.150
Command Control and Intelligence (C2I)	.200
Otherwise	.000
TOTAL	1.000

4.4.4.2 Utilities Tables. These tables represent in each row the utility values of the different Functions with respect a Component. For instance, in Table 4.2, for the Component Air Battle (Air Bat.) the Function value of Combat Readiness (CR) has a value of .85, and the Function Air Defense (AD) has a value of .90, and so on.

4.5 Conclusion

This chapter has explained the sources of the data used in the analysis, that is, how to obtain the different values of the weights and utilities, and which are the appropriate authorities to assign them in each case. Also we have defined the

"Spanish Air Force Current Status", which will be the basis for further comparatione between new weapon systems.

With this last step, the whole decision tree has been defined. In the next chapter, the possible employment of the process in the Spanish Air Force planning system will be described. The decision tree will be used to assess the acquisition of a new weapon system under the set of values which have been given.

V. Demonstration

5.1 Introduction

The defined scenario and the current weight and capabilities of the Spanish Air Force are the base for a discussion of how to use the proposed system in an analysis. For demonstration purposes we will discuss how to compare two different weapons system.

These weapon systems are candidates to replace an old system. In this thesis, we will compare the European Fighter Aircraft (EFA), and the Advanced Tactical Fighter (ATF), as replacements for the current Mirage F-1 in the Spanish Air Force. Part of the goal will be to at least maintain the current capabilities, under the misisons and scenarios defined in the third Chapter of this thesis.

5.2 Discussion

The differences between the two weapon system are their capabilities or utilities for the different tasks. For example, let us say that the AFT has higher performances than EFA in Counter-offensive, Interdiction, and Surface Battle, but EFA is better than ATF in Air Battle. This means, that, in the defined tree, we have to supplement in each case the current utility values with the new values.

The values would be provided by the experts, and would be based on a determined number of aircraft available in each case. The budget and the different cost of each plane define the number of EFA or ATF that it would be possible to buy. These numbers normally would not be the same. The actual number of airplanes are not directly important, as it is the total utility of a *system* that is the important consideration. Consequently, we will consider the utility of the total force structure, implicitly assessing the utility of the numbers of aircraft.

5.2.1 Values

5.2.1.1 Weights. The weights for all level branches will remain the same already defined, because it is supposed that the political circumstances and threats will remain constant regardless of the system chosen. We have further assumed that the decision tree will remain the same for this thesis purpose, at short and medium planning time horizons.

5.2.1.2 Utilities. These new values will be the utility values that the Air Force Expert Team (AFET) assesses for the different functions once the new weapon system (EFA,ATF) has been included in the Air Force inventory. Consequently, these values will show the different capabilities of the two weapon systems, giving higher values for the EFA in Air Battle, and for the ATF in Counter-offensive, Interdiction, and Surface Battle, using the assumptions established in the previous paragraph. Having defined the utilities for the total force using each weapon system, the initial optimal choice is to acquire the system with the higher value (as reported at the top of the tree). This choice is conditioned on the results of a sensitivity analysis.

The assessed utility values for EFA are in Appendix S, and for ATF are in the Appendix T. They change from the utilities for the current system because of the replacement of an old weapon system by a new one. In general, the effect is to increase the effectiveness of the total system when we compare the improved with the "Current Status", before mentioned. In fact, in some cases the utility value of a new weapon system could decrease respect the value of the former weapon system.

The specific utilities that change depend on the weapon system itself. For instance, in the case of fighter aircraft, the airlift utilities won't change very much. Only the values of functions directly affected by the performances of the new weapon system will change significantly.

In this case the change in utilities will in the following sense: The EFA utilities, will increase mainly in the Air Battle, Interdiction, and Counter-offensive Components, when they are related with the Combat readiness, Air Defense, Air Offense, Interdiction, and Electronic Warfare functions. This is primarily because, although the EFA is a multi-role aircraft, it has a priority use in air-air missions.

The ATF utilities, will increase mainly in the Surface Battle, Interdiction, and Counter-offensive components, when they are related with the Combat readiness, Interdiction, Tactical Air Support Maritime Operations (TASMO), Close Air Support (CAS), Electronic Warfare, and Suppression Enemy Air Defenses (SEAD) functions. This is because the aircraft has an excellent performances in Tactical Operations, and radar signature.

The different weights and utilities for the current Spanish Air Force have been defined, so we know its current capabilities. It will be the standard against which the two alternatives (EFA,ATF) will be measured. Now, the utility values for the two new alternatives weapon systems, the EFA and the ATF are known. When we compute these values using the software, it will be possible to see the results of incorporating the candidate weapon systems in an effort to better meet the Spanish Air Force requirements.

It is equally important to perform a sensitivity analysis and look at the changes that a chosen strategy could suffer in response to a change in the weights at some selected branch (or level) of the tree. This can be very important in analytically responding to the vagueness inherent in politically derived numbers.

5.3 Software

The software that we will use is the Decision Analysis Support System (DASS). This package has been used because it allows us to deal with very large decision trees. It allows us to set up all the weight values in the different branches, as they are in the Appendixes. Also we can insert all the utilities values at the end of each branch. Then the full tree can be evaluated, and the different utilities values for each weapon system at every different level can be extracted.

The DASS is an experimental package, with which we can create decision or chance nodes. In each node we can give a short explanation of its purpose, and assign a name to the node. Every node can have some descendants called "children". For a child node the node from which it was created is called the "parent." Each node throughout the decision tree has a path and at the end of this path will be its own name, preceded by its parents name.

We can weight the different branches from each node, and at the end of the decision tree we can set the utility values. Once the decision tree has been created, and all the values are known, we can evaluate the decision tree at every level. It is possible to study, and evaluate up to six different alternatives at the same time.

The program can also show a sensitivity analysis, for a user-selected node. It does this by representing the values at this point in a graphic display, from which we can immediately see which weight values will change the preference between alternatives.

5.4 Validation

Since this is an demonstration problem, we can validate the data and the methodology only by inspection. By looking at the different outputs, and comparing them with the expected results that logic and the experience advise, we can validate the model based on observations of appropriate outputs. Were actual data to be used, a validation of the model could be done using the commensurability technique, which was stated in Chapter IV. This is a method with which to check the different weights, as well as the utilities specified.

We are going to compare the outputs given by the program with the expected outputs in two different cases. It is clear that for facing a East threat, the Spanish Air Force will need more an aircraft as the ATF. In the other hand, facing a threat from the South, an aircraft as the EFA will be preferred.

The former case has been represented in the definition of the decision tree for this thesis. In this case, a threat from the South (.5), has a higher weight than a threat from the South (.4), as was establish in Chapter IV. With the given values we have obtained utility values as follows:

Current Status	.724
European Fighter Aircraft (EFA)	.799
Advanced Tactical Fighter (ATF)	.774

This result shows that for the weights given, where we have a high priority for NATIONAL scenarios, with a higher threat from the South, the EFA is more preferred than the ATF. This is normal, becausc facing a South threat the Air Defense is much more important than the other Components. Thus a Fighter is more useful than a Tactical airplane.

Now we will flip the different weights, in order to show a big threat from the EAST, and a NATO scenario instead a NATIONAL one. Then using the same utility values that where assessed in different scenarios, but with the weights as follows:

THREATS (Level 1):	EAST=.8	WEST=.1	SOUTH=.1
ALLIANCES (Level 2):	NATO=.8	NATIONAL=.2	

we have obtained the following values:

Current Status	.750
European Fighter Aircraft (EFA)	.792
Advanced Tactical Fighter (ATF)	.798

This results show a higher preference for ATF than for EFA. This is normal, because facing a East threat the TASMO, and all tactical missions are much more important than the other Components. Thus a Tactical/Fighter is more useful than a pure fighter airplane.

The model as defined seems to work well enough, From further sensitivity analysis we could conclude that the model represents, in an appropriate way, the different scenarios, and could be useful for the assessment of different weapon systems. Then we could conclude that it is an validated model for a Spanish Air Force planning system.

The model can be considered validated because its response to changes in values is as expected, because the model response to different scenarios is adequate, and the final utility values obtained in different scenarios are consistent with expectations. This means that, depending of the scenarios, we will obtain different utilities, because the role of the aircraft is more adequate for certain scenarios better than in others. For instance, the ATF received different values in the cases that we explained before, .798 and .774, which implies that it will perform its missions better in one scenario than in the other. We can see also that the EFA utility value increases by a very small value, because its performances for both scenarios are almost the same. The next step will be to perform an automated sensitivity analysis, in order to know which values produce a change in the decision.

5.5 Sensibility Analysis.

The software used (DASS) allows us to make a sensitivity analysis to see which weights are most important. There could exist weights for which the answers are very sensitive. This means that a small chage in these values could change the decision. The analyst has to be very careful at those points, and must show the decision maker the importance that these assessments of weights have on the final answer.

For this thesis demonstration, we have chosen the second set of values used in the validation (Chapter V, page 5-5), where the values are as follows:

THREATS (Level 1):	EAST=.8	WEST=.1	SOUTH=.1
ALLIANCES (Level 2):	NATO=.8	NATIONAL=.2	

When, with these values, after evaluating the tree we go to the second level and ask the program for a sensitivity analysis, we get the graphics in Appendix U. In the first case, for the NATO study where the weight value is .8, we got the following values:

	LOW VALUE	HIGH VALUE
NOW	.689	.765
EFA	.760	.800
ATF	.728	.816

where NOW represent the current status.

These values show that for a low weight value for NATO in Level 2, the EFA alternative is preferred, meanwhile for a high weight value the ATF alternative should be chosen. There is a weight value, in this case roughly .7, where both alternatives have the same utility value. In this case, this value (.7), is very close to the real weight value for the NATO alternative (.8), which means that we have to be very careful with cases like this one, and let the decision maker know the risk that a slight change in the weight value could result in a change in the final decision. At the same level, in the NATIONAL case, we have a similar feature but the preferences toward EFA and ATF are reversed.

5.6 Conclusions

In this chapter, we have demonstrated the model, and using the Decision Analysis Support System, we have obtained values that agree with the expected values. Also we have discussed validation of the the model and demonstrated the use of sensitivity analysis. In every case we have to study the decision tree looking for the possible break points where the final decision could change with a slight change in the relative weights. These points are very important for the decision maker, and it could help him to know them in order to be more confident in his own decision. The appropriate validation must be done in each decision tree, to make us sure about the appropriate behavior of the decision tree according with the data available and the experience.

VI. *Conclusions and Recommendations*

6.1 Conclusions

Taken in consideration, in this thesis we have presented the sketch of a new planning system, because in the real world the problem is much bigger and complicate. The creation of the expert teams, and the appropriate definition of the strategies will be the cornerstone of this new process.

We can say that the new planning process defined in this thesis has the required performance and reaches the goals proposed. Some of the achievements of this process are as follows:

1. To merge in a unique process the different commitments of the Air Force with two National Defense Planning System, and participating in the NATO Planning System.
2. To create a flexible process, which can respond to rapid changes, and able to compare different weapon systems, and also useful in a Force Structure definition..
3. To represent the different activities, tasks, or missions that the Air Force can carry out in the several scenarios.
4. To apply the Operation Research techniques in the process, trying to avoid a possible human factor error or misinterpretation of the problem.
5. To make the planning process useful for different services, countries, or communities, facing the same or similar kind of problem. In each case it will be necessary to fit the decision tree to the particular problem.

The process has been considered here, in a such dimension that could be handle for the purpose of this thesis, and at the same time could represent clearly an example. The methodology demonstrate could be applied to problems larger than the one explained in this thesis, and the process is still valid.

We have demonstrated a methodology for the special case of the Spanish Air Force, but even in this case the way to define the different threats or Mission Area Analysis (MAA) could be other than the notional structure presented. The planning process could follow a similar structure , changing the name or number of the different branches of the decision tree.

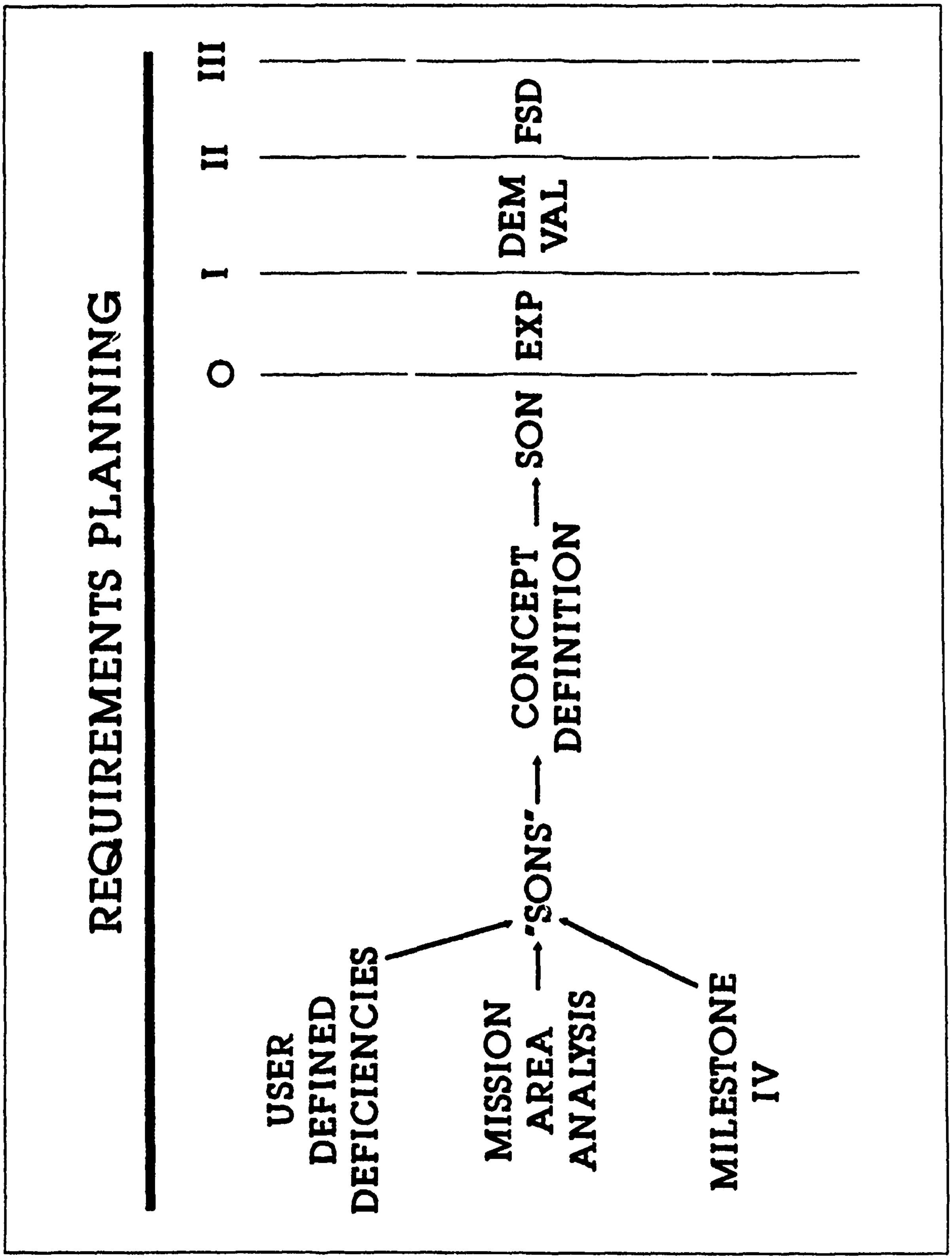
6.2 Recommendations

From the ideas expressed in this thesis, we can make some recommendations in order to improve this research, and implement the Decision Analysis techniques in the Air Force planning system.

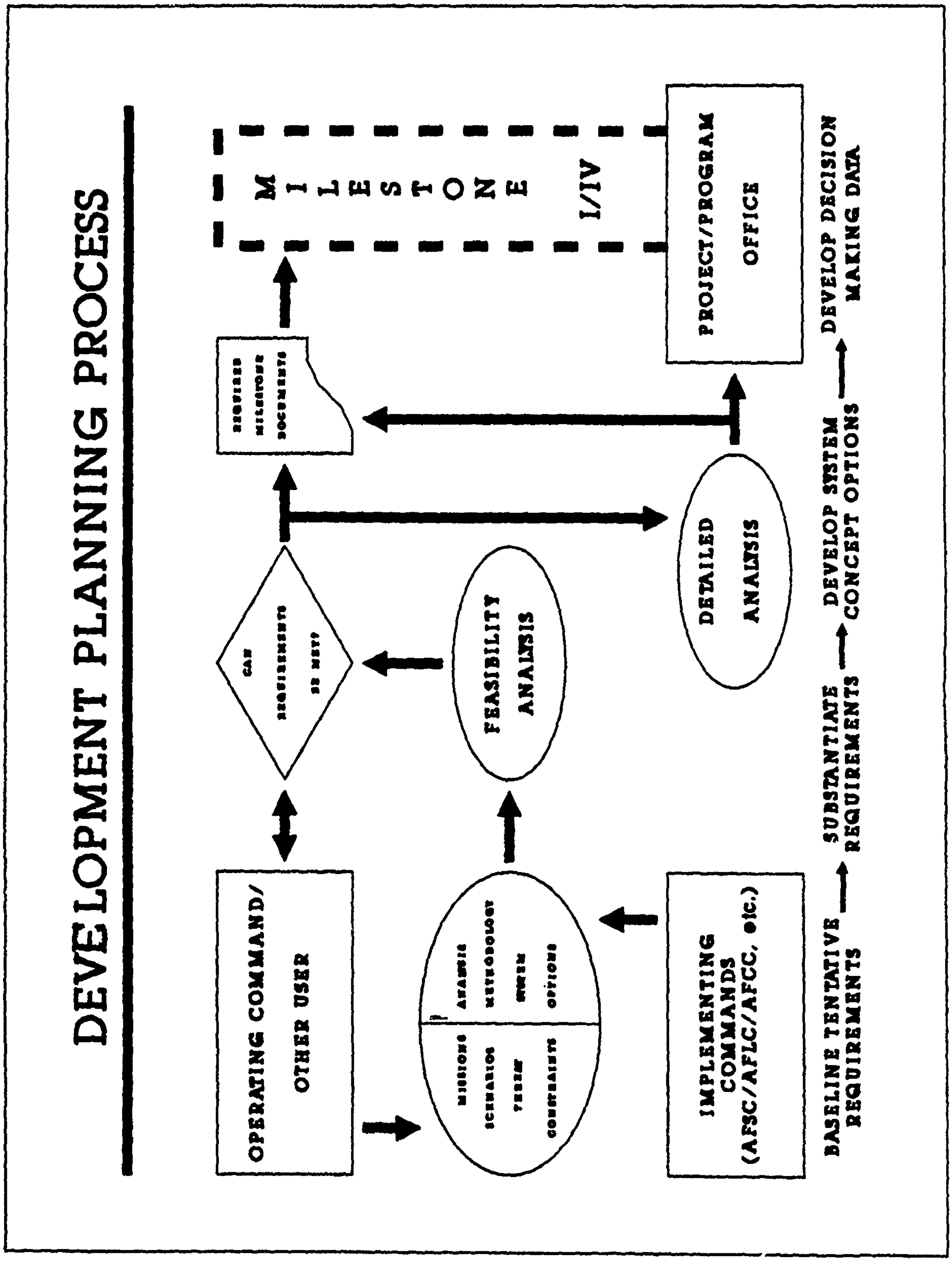
Some of this recommendations are as follows:

1. To improve the process, and implement it if the appropriate authorities of Spanish Air Force consider that convenient.
2. If the process were implemented in the Spanish Air Force, to present and recommend it to others Services, or NATO authorities.
3. To improve the software for facing very large problems, and the inputs and outputs.
4. To make a realistic test of the methodology as a common project between the Logistic and Engineering Schools in Air Force Institute of Technology (AFIT). In this case of the USAF, both schools could create the expert teams for the appropriate assessments, and studying the results for some particular weapon system.

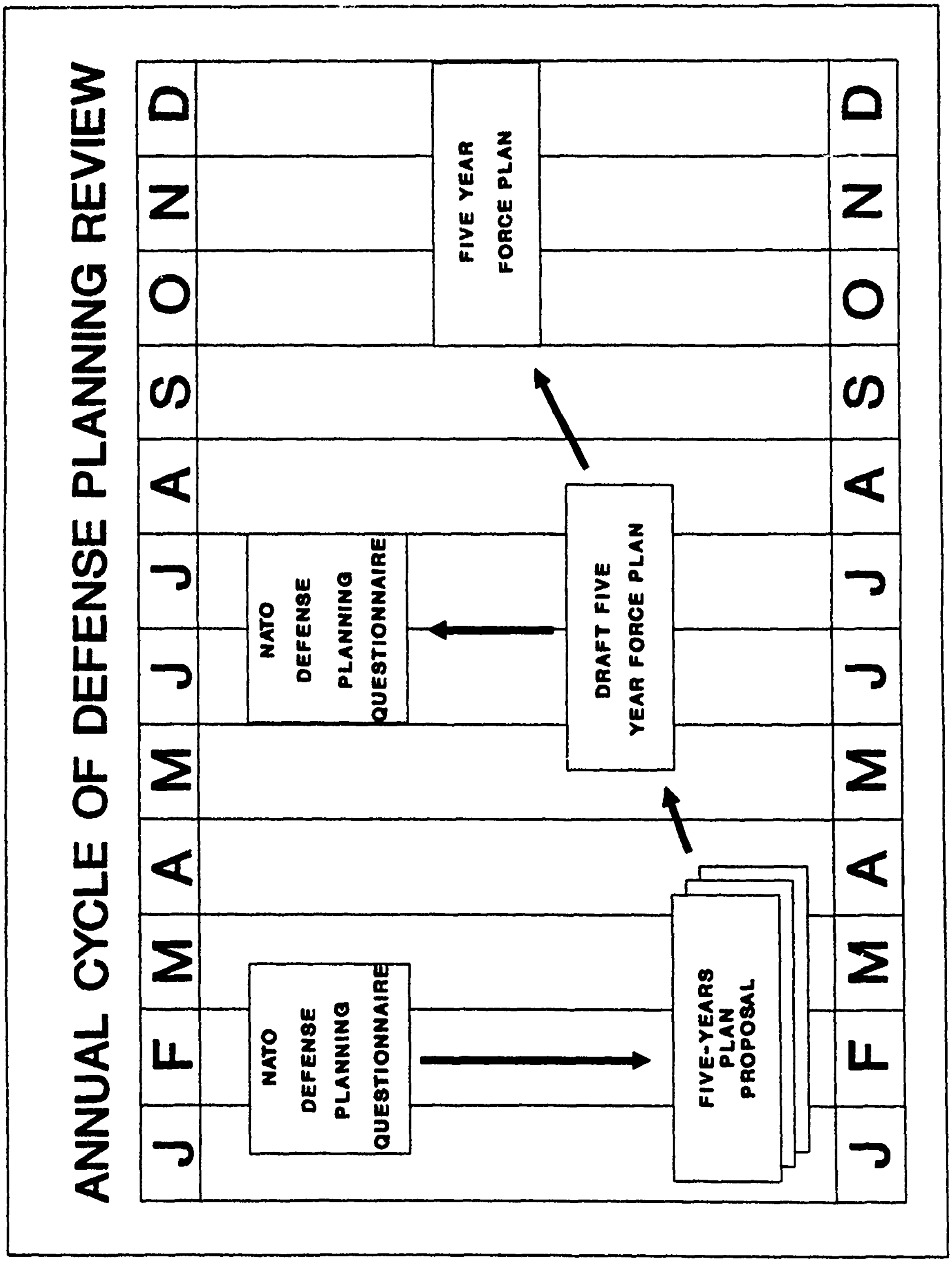
Appendix A. *USAF Planning Process.*



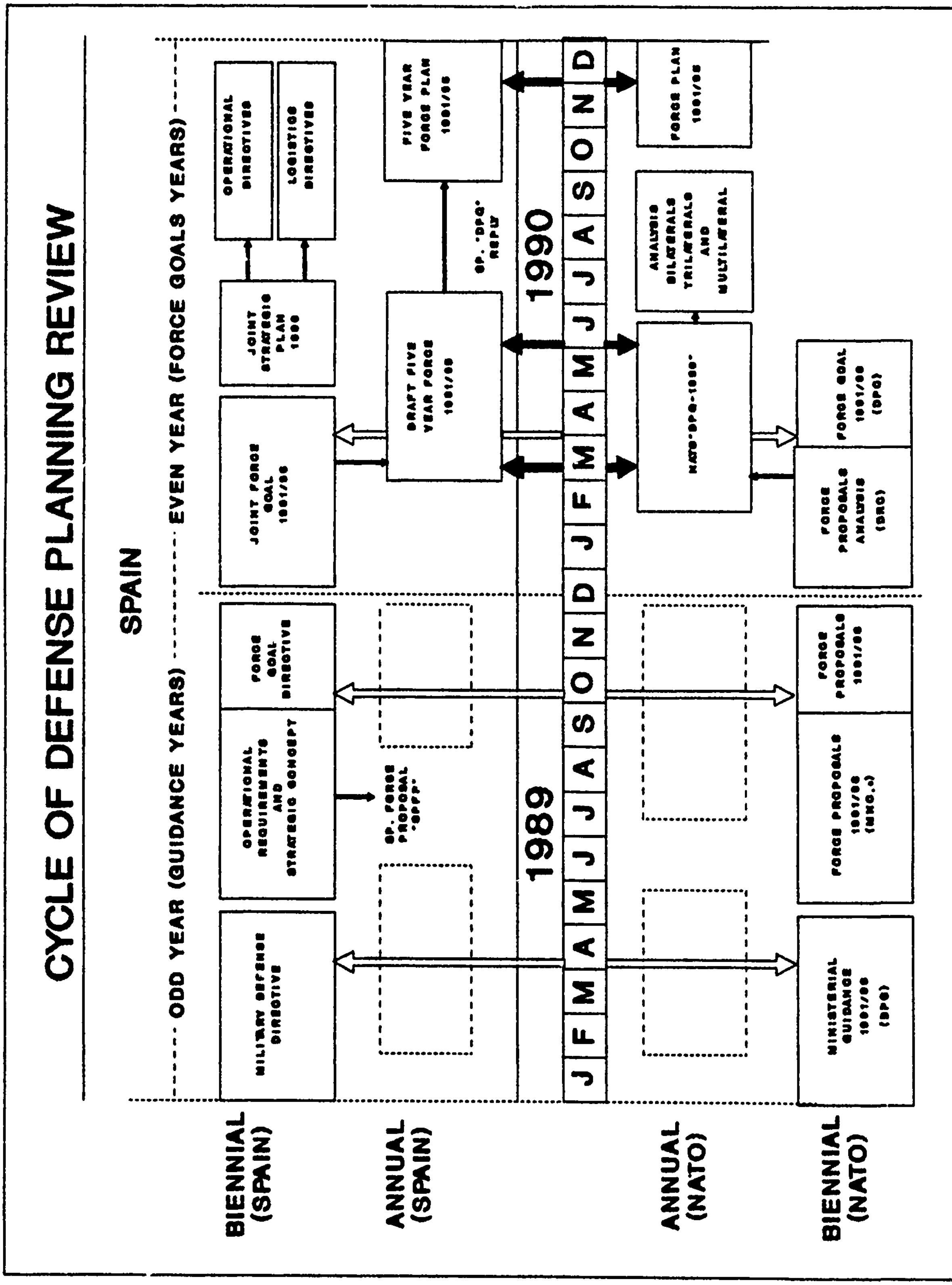
Development Planning Process.



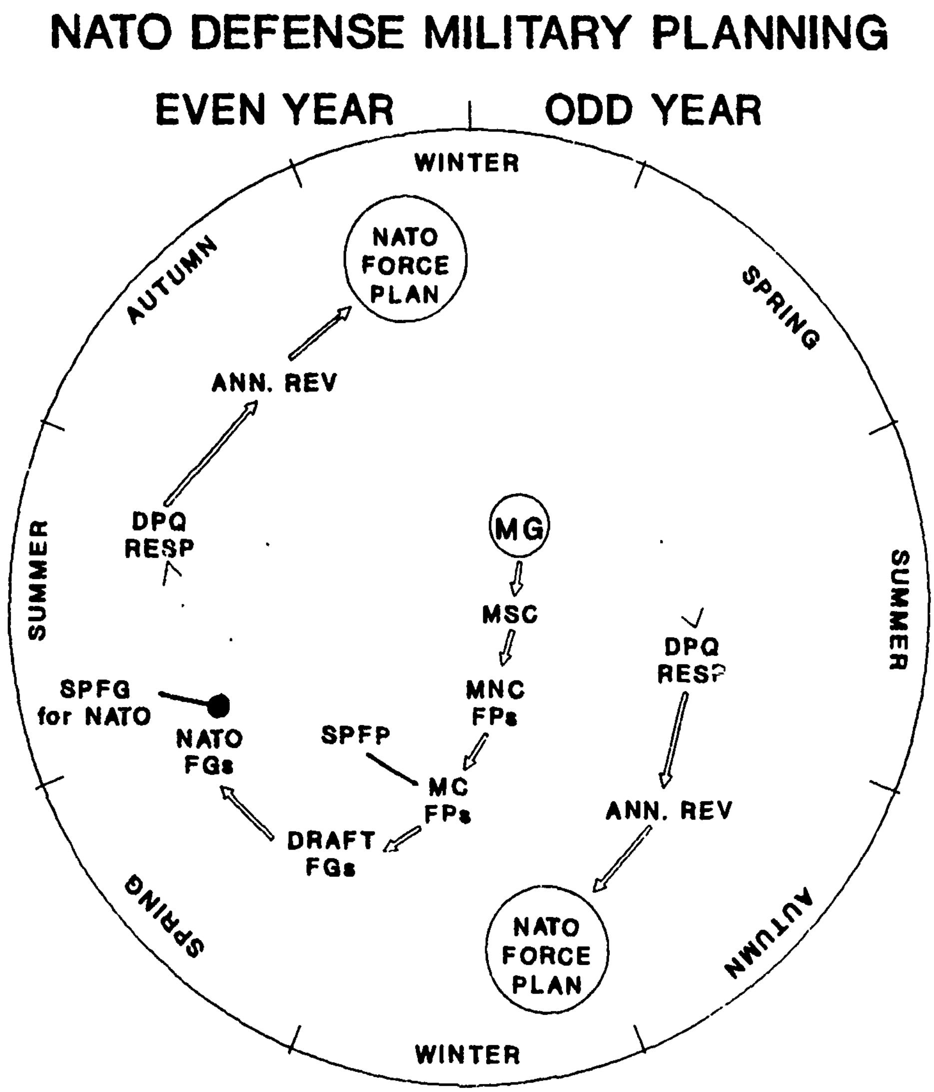
Appendix B. *NATO Defense Military Planning.*



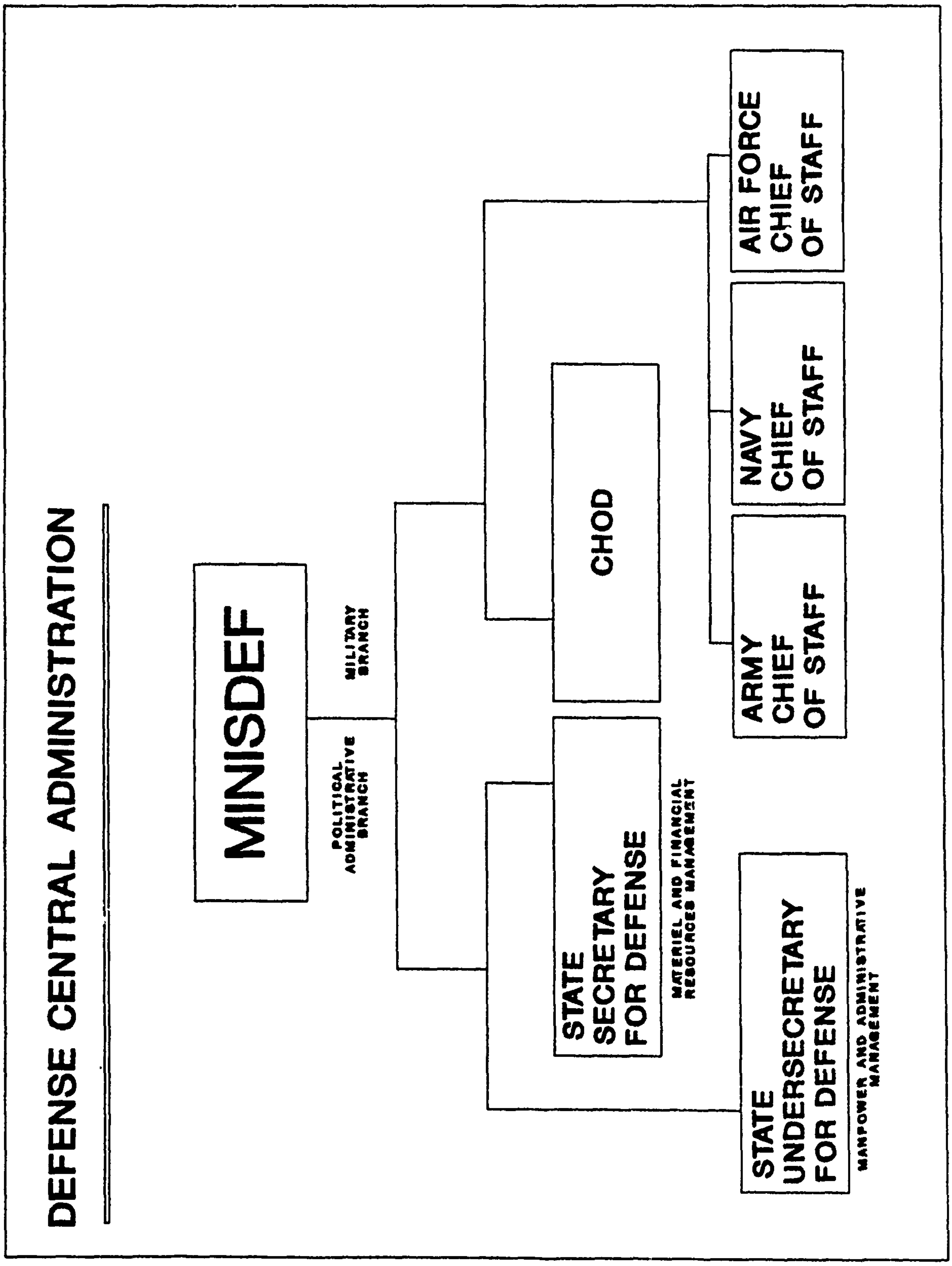
NATO and Spanish Cycles.



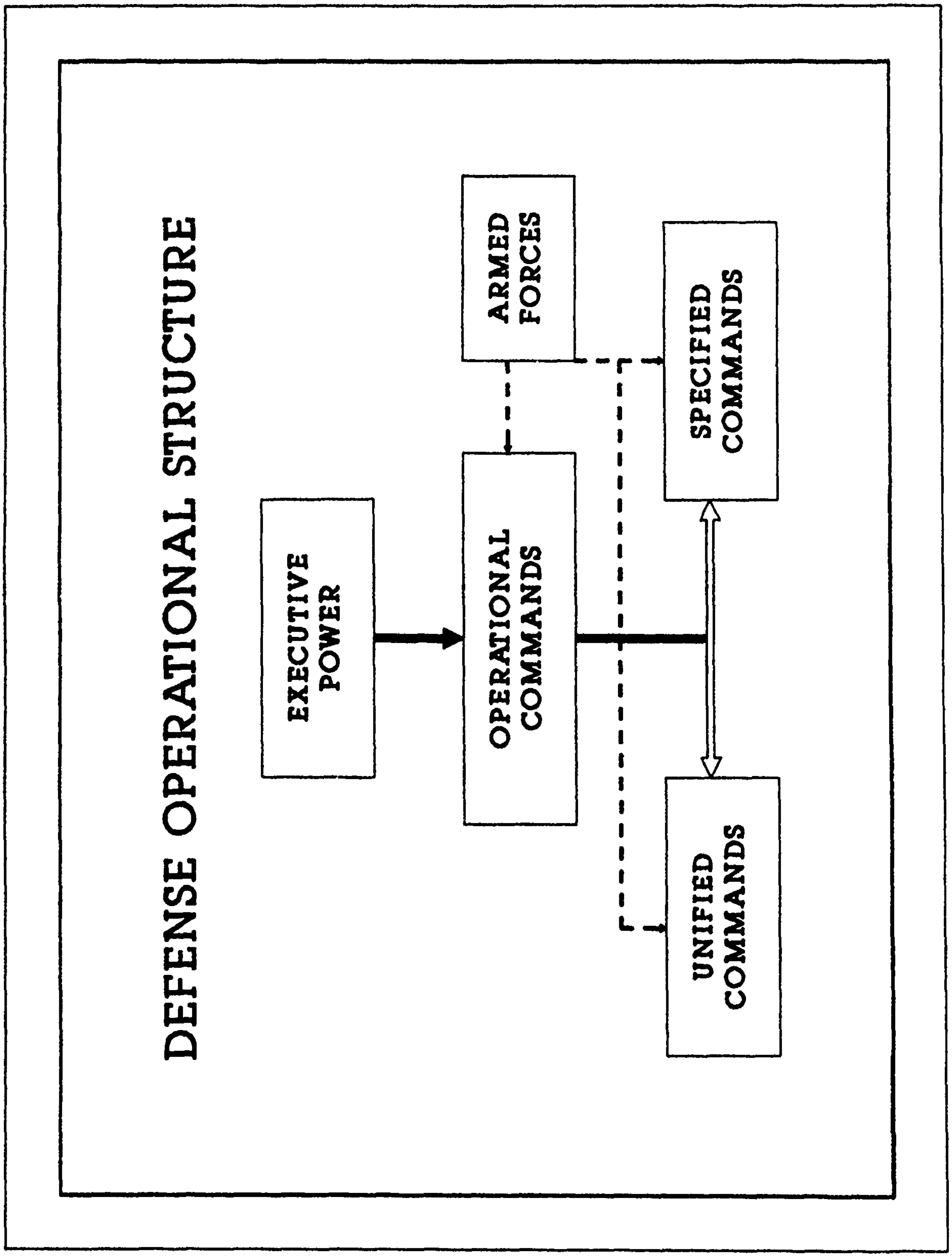
Appendix C. *NATO Force Goals.*

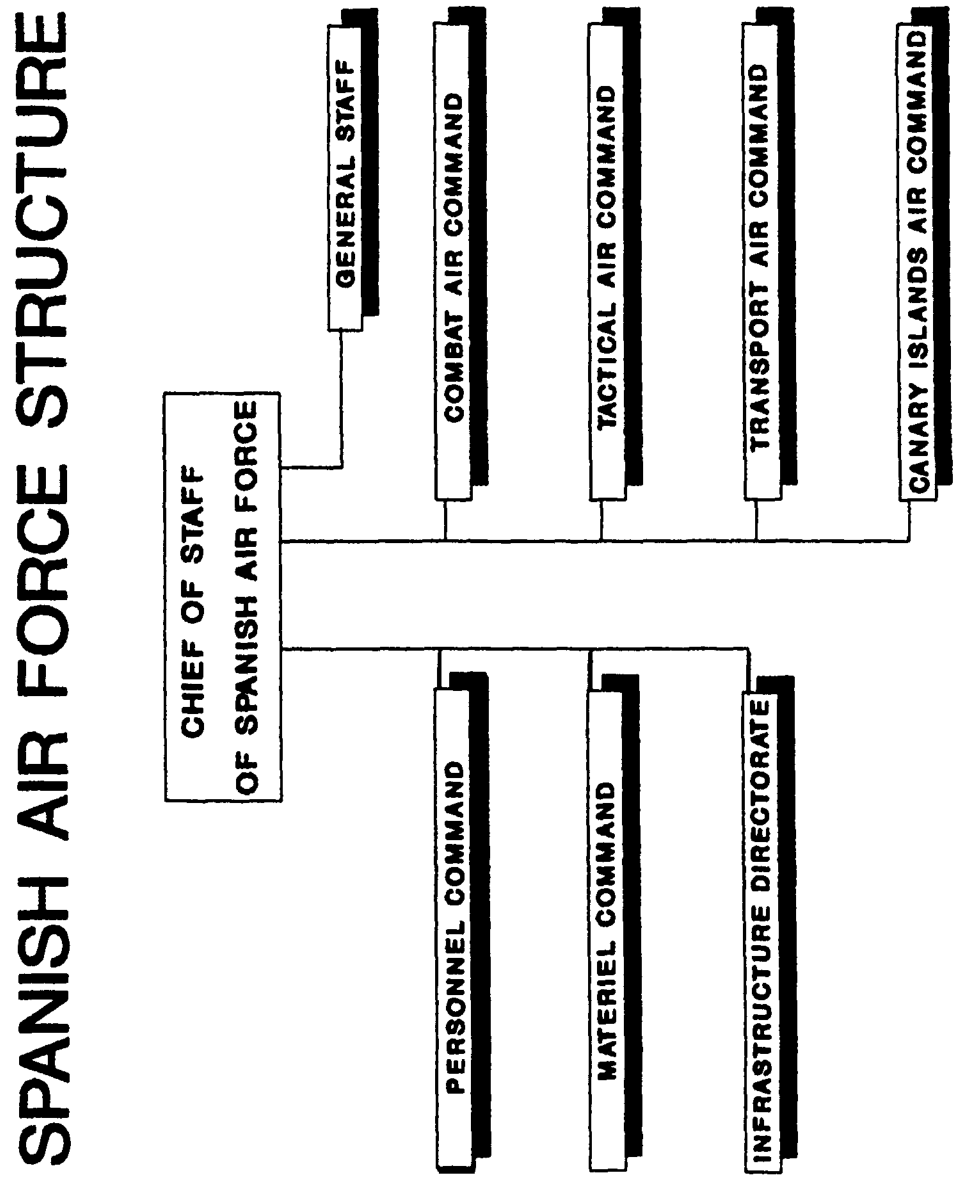


Appendix D. *Spanish Defense Central Administration.*

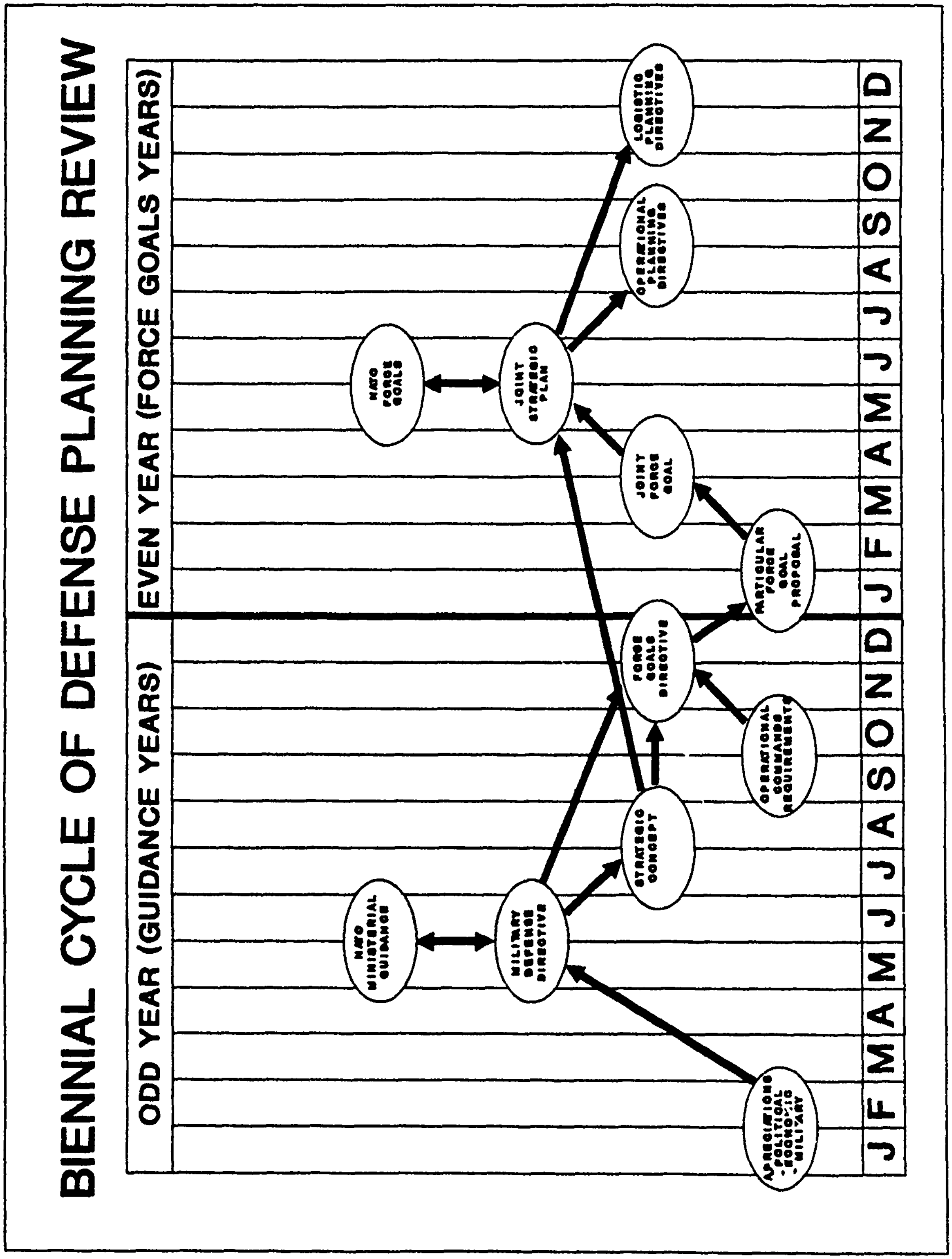


Defense Operational Structure.

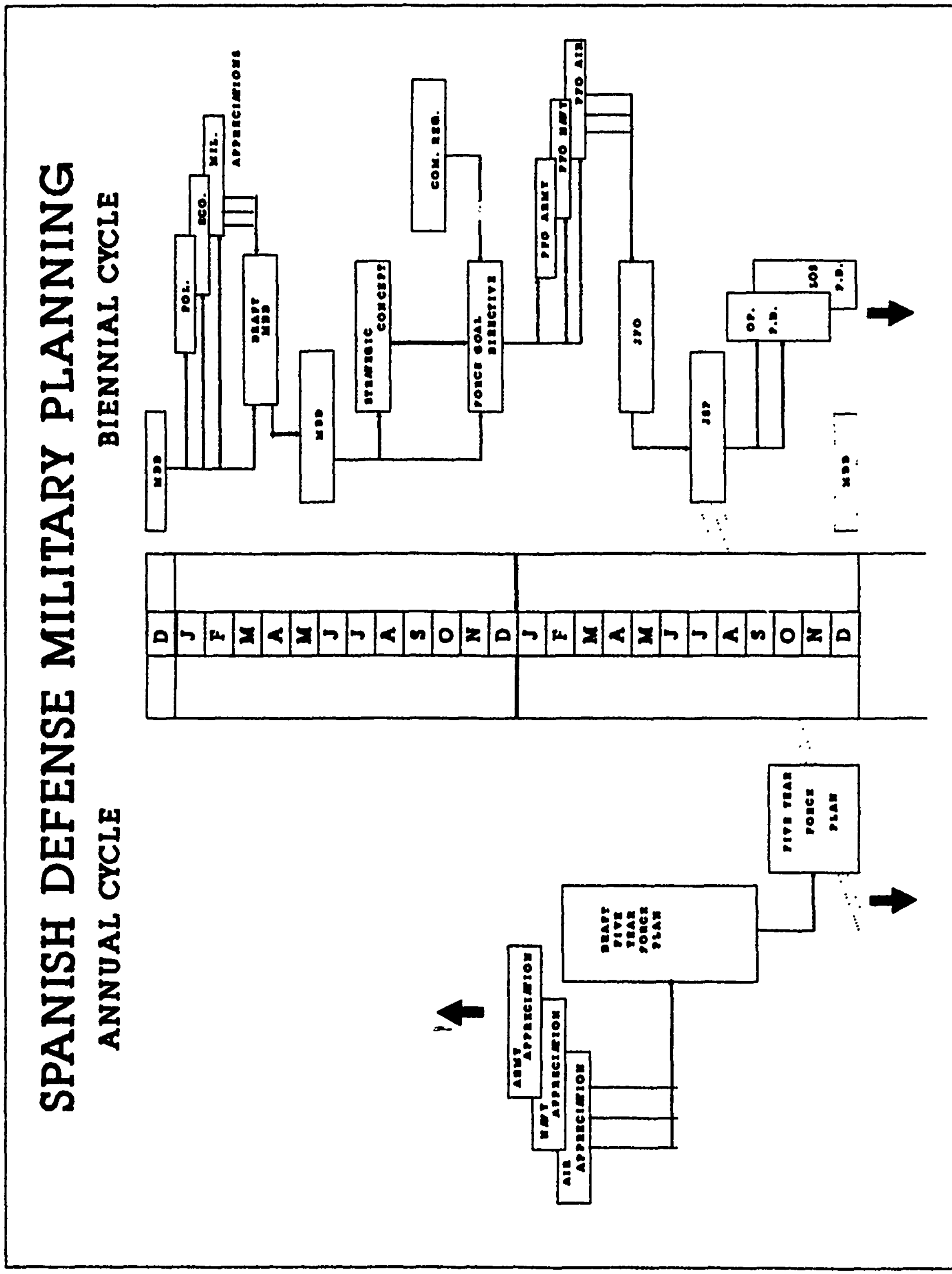



SPANISH AIR FORCE STRUCTURE
CHIEF OF STAFF OF SPANISH AIR FORCE
GENERAL STAFF
COMBAT AIR COMMAND
TACTICAL AIR COMMAND
TRANSPORT AIR COMMAND
CANARY ISLANDS AIR COMMAND
PERSONNEL COMMAND
MATERIEL COMMAND
INFRASTRUCTURE DIRECTORATE

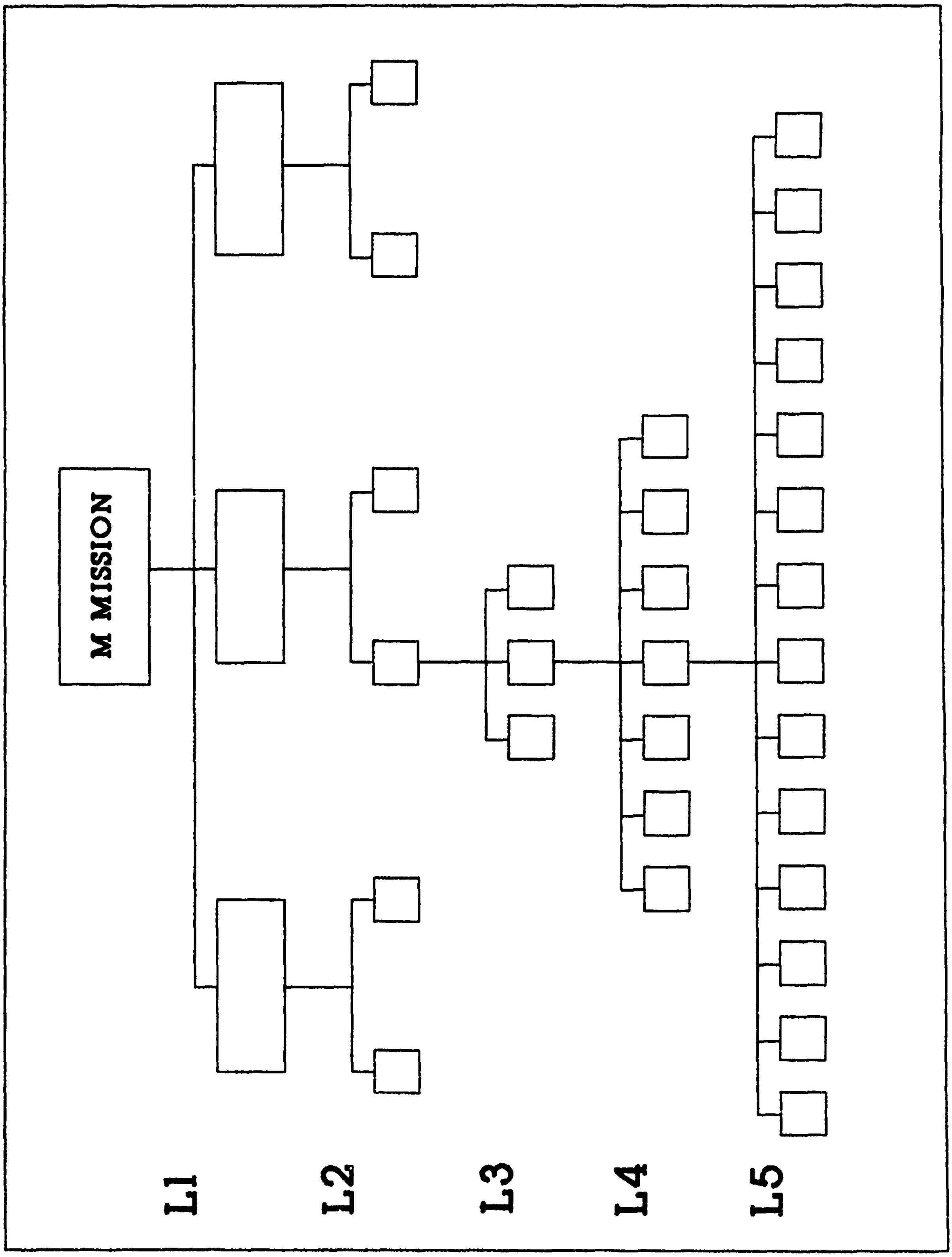
Biennial Cycle of Defense Planning.



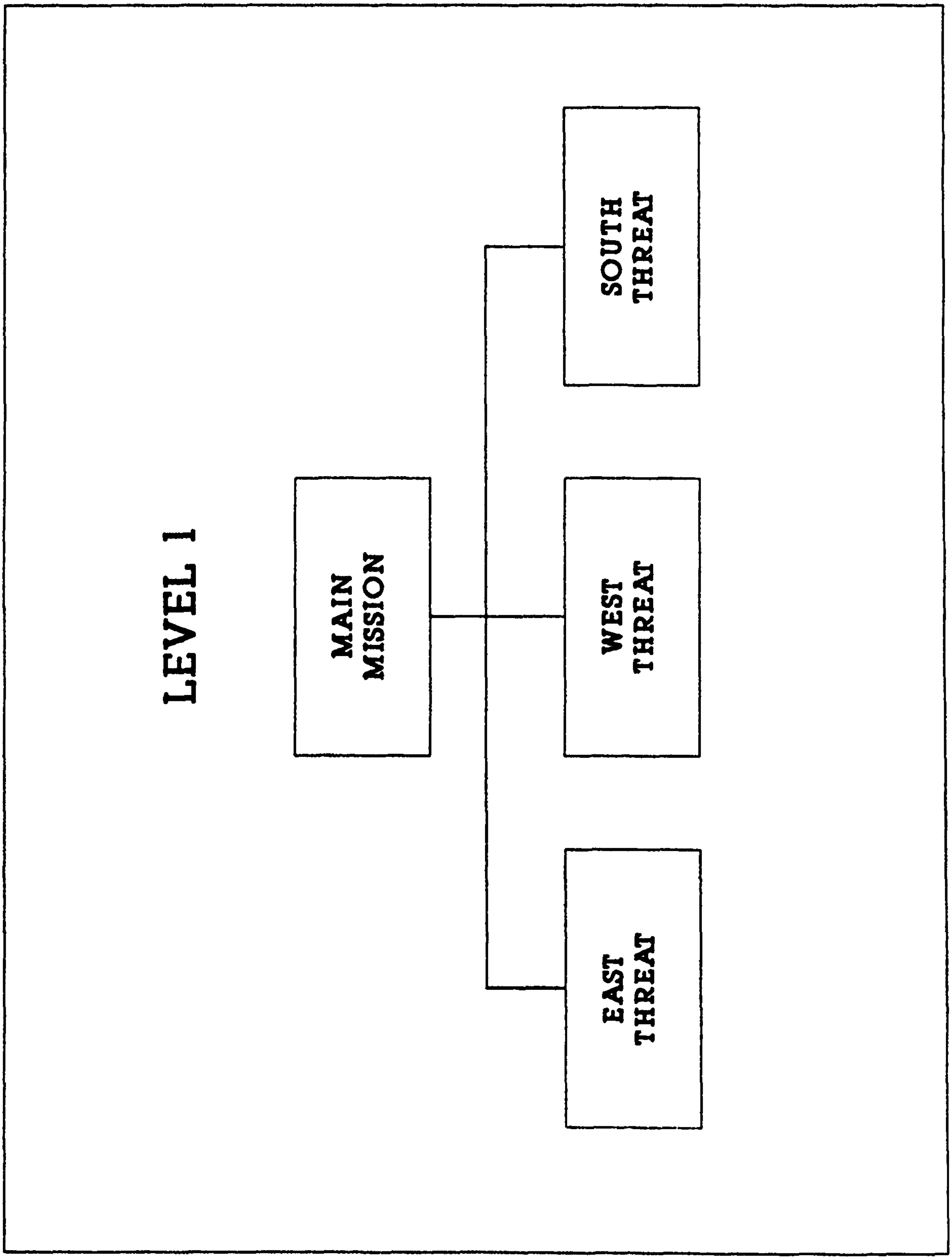
Annual and Biennial Cycles.



Appendix F. *Decission Analysis Tree - General Overview.*

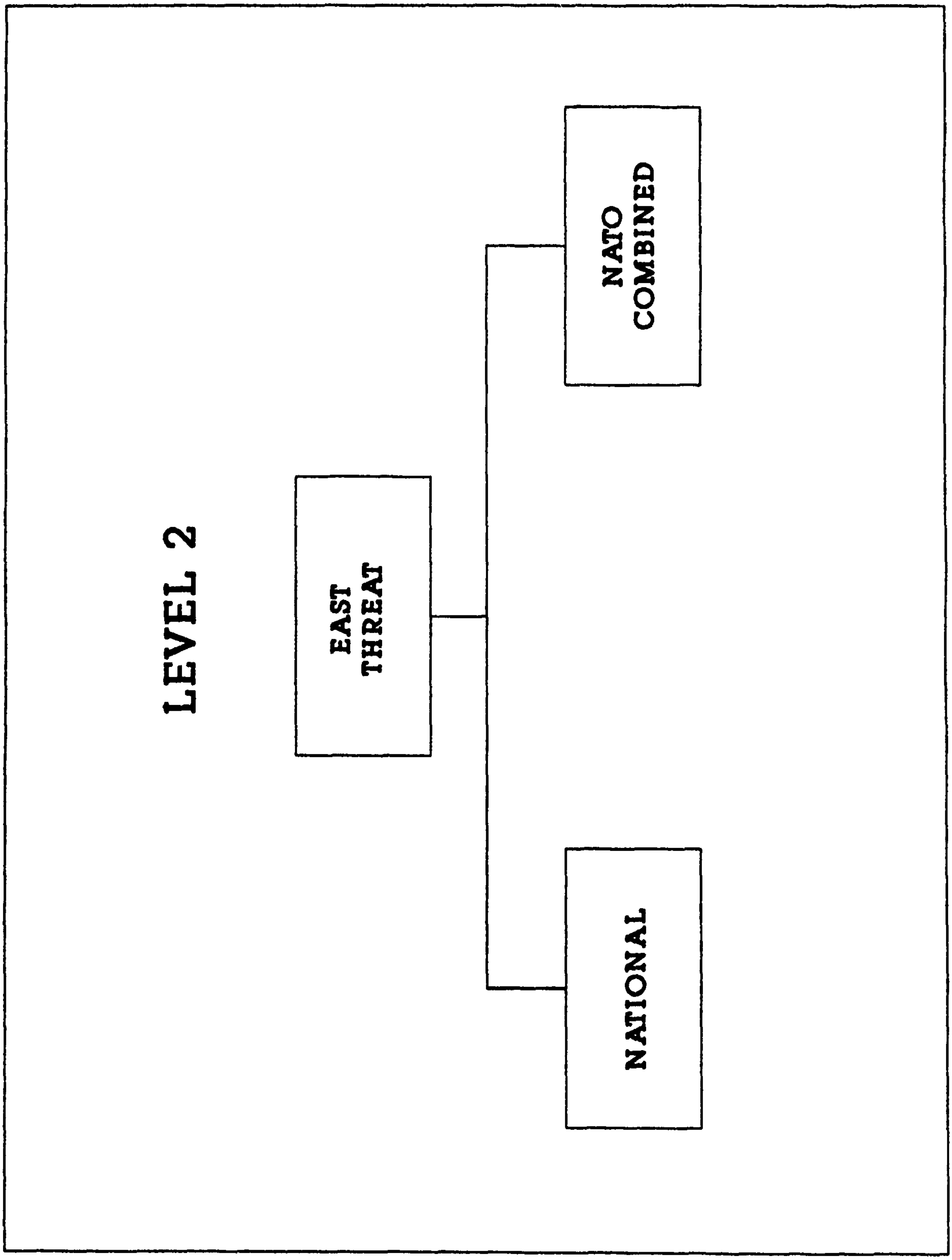


Appendix G. *Decision Analysis Tree - Level 1 - Threats.*

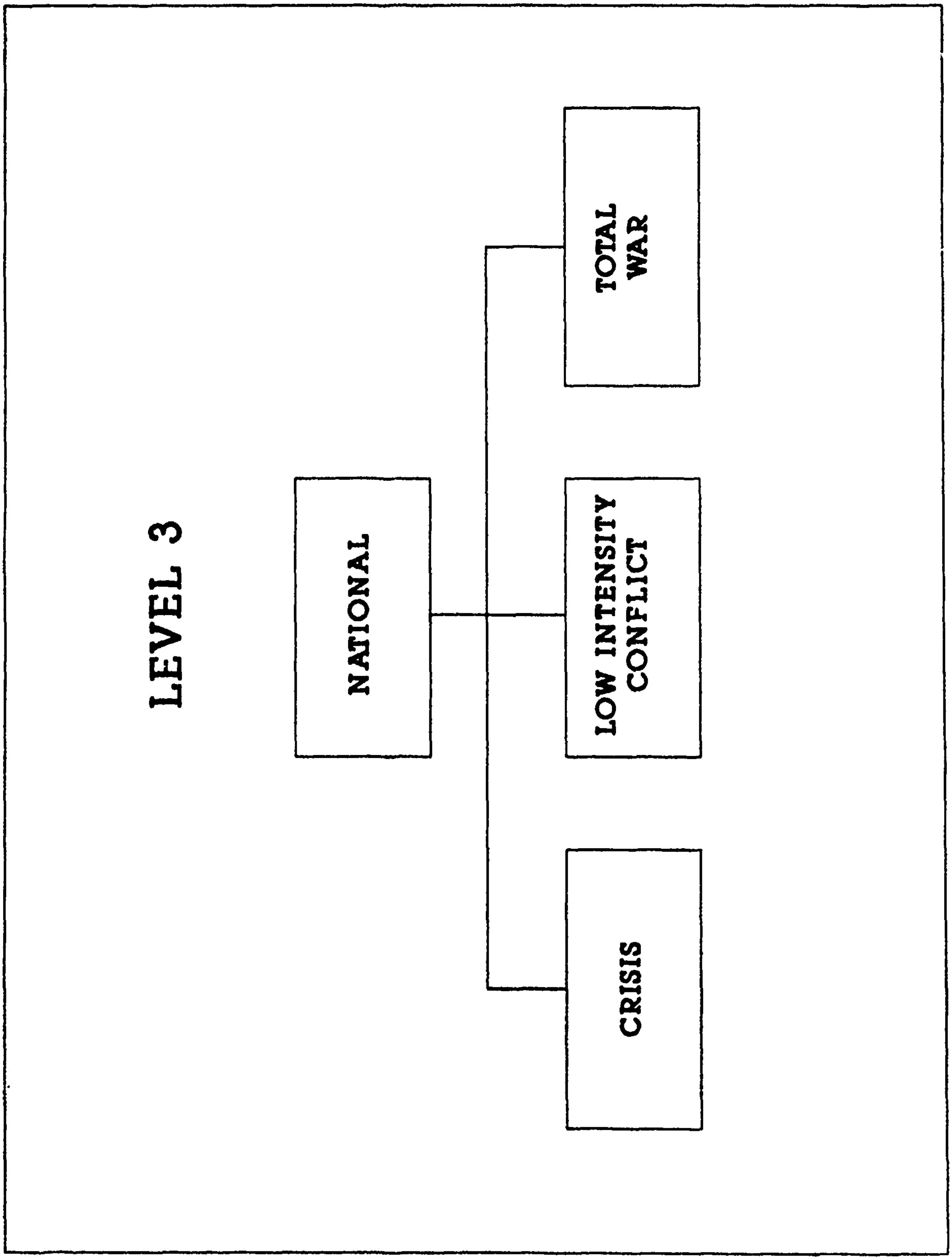


Spanish Scenario.

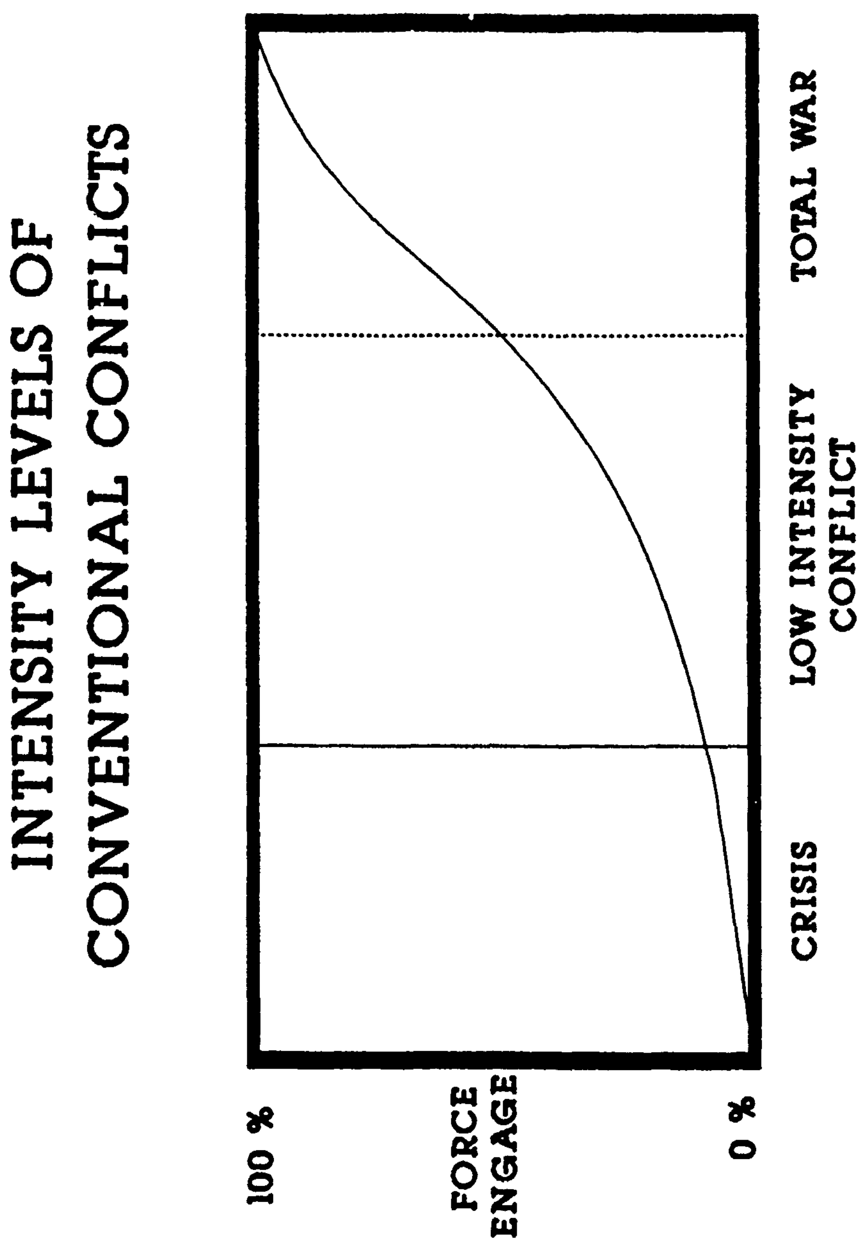
Appendix H. *Decision Analysis Tree - Level 2 - Alliances.*



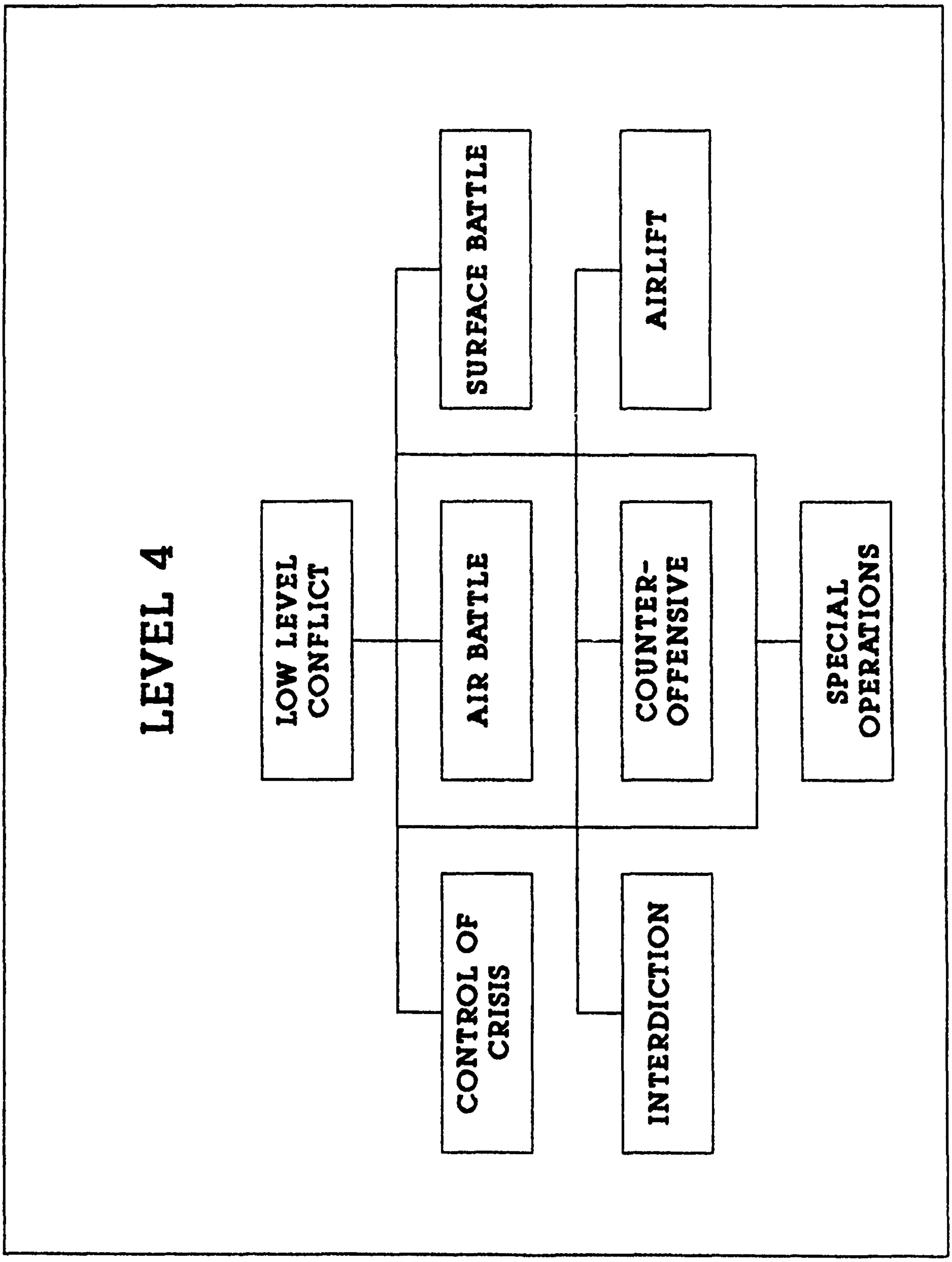
Appendix I. *Decision Analysis Tree - Level 3 - Conflicts.*



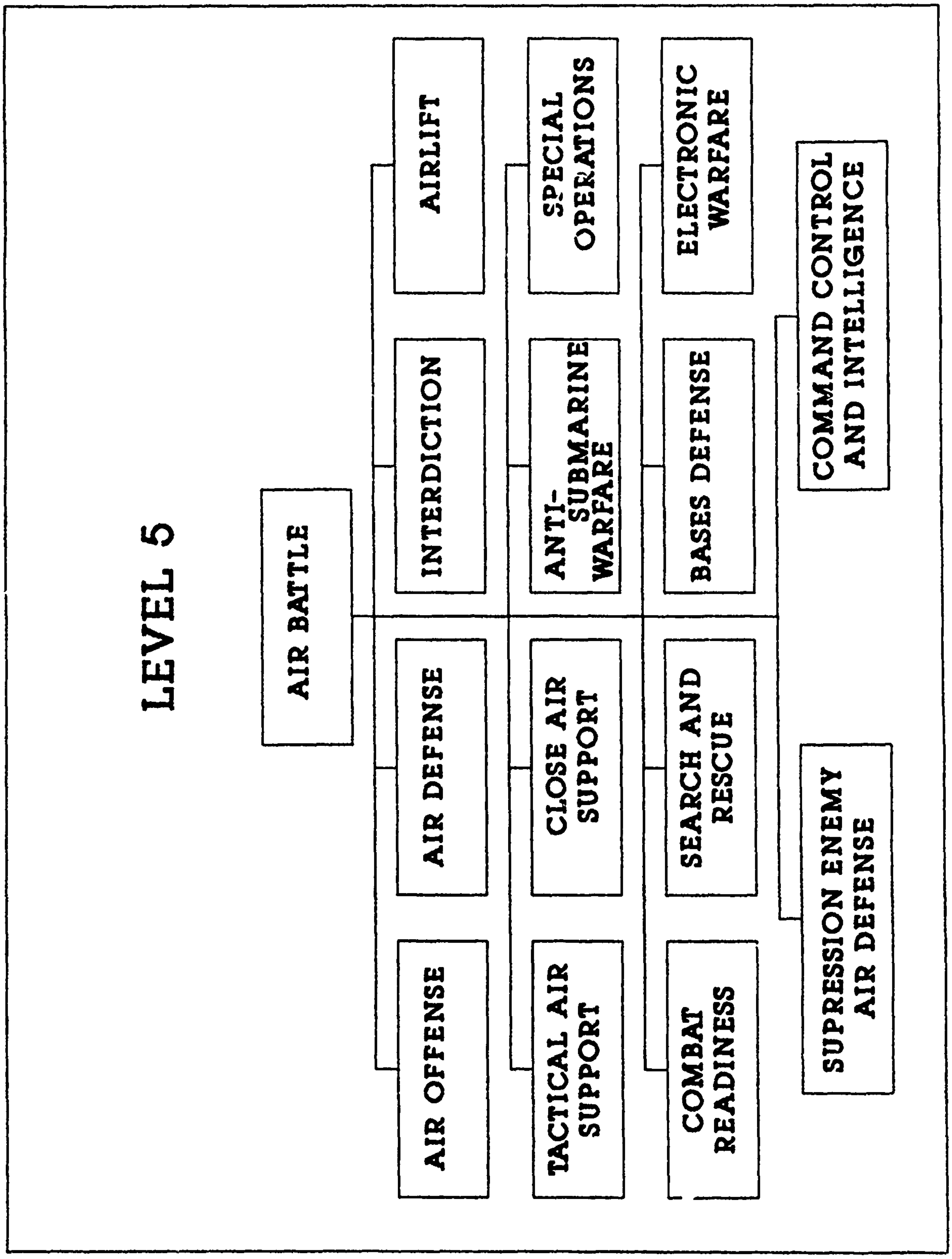
Appendix J. *Intensity of Conventional Conflicts.*



Appendix K. *Decision Analysis Tree - Level 4 - Components.*



Appendix L. *Decision Analysis Tree - Level 5 - Components.*



Appendix M. *Function Definitions.*

COMBAT READINESS (Operational readiness)(CR): Is the capability of a unit/formation, ship, weapon system or equipment to perform the missions or functions for which it is organized or designed. May be used in a general sense or to express a level or degree of readiness.(JCS Pub 1)

AIR DEFENSE (AD): All defensive measures designed to destroy attacking enemy aircraft or missiles in the earth's envelope of atmosphere, or to nullify or reduce the effectiveness of such attack.(JCS Pub 1)

AIR OFFENSIVE (AO): Sustained operations by strategic and/or tactical air weapon system against hostile air forces or surface targets.(JCS Pub 1)

AIR INTERDICTION (AI): Air operations conducted to destroy, neutralize, or delay the enemy's military potential before it can be brought to bear effectively against friendly forces at such distance from friendly forces that detailed integration of each air mission with the fire and movement of friendly forces is not required.(JCS Pub 1)

TACTICAL AIR SUPPORT MARITIME OPERATIONS (TASMO): Air operations carried out in co-ordination with surface forces and which directly assist maritime operations. (JCS Pub 1)

CLOSE AIR SUPPORT (CAS): Air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.(JCS Pub 1)

ANTI-SUBMARINE WARFARE (ASW): Operations conducted with the intention of denying the enemy the effective use of his submarines.(JCS Pub 1)

AIRLIFT (Air logistic support)(AL): Support by air landing or airdrop, including air supply, movement of personnel, evacuation of casualties and prisoners of war, and recovery of equipment and vehicles.(JCS Pub 1)

SPECIAL OPERATIONS (SO): Secondary or supporting operations that may be adjuncts to various other operations and for which no one Service is assigned primary responsibility.(JCS Pub 1)

SEARCH AND RESCUE (SAR): The use of aircraft, surface craft, submarines, specialized rescue teams and equipment to search for and rescue personnel in distress on land or at sea.(JCS Pub 1)

BASE DEFENSE (BD): The local military measures, both normal and emergency, required to nullify or reduce the effectiveness of enemy attacks on, or sabotage of, a base, so as to insure that the maximum capacity of its facilities is available to U.S. forces.(JCS Pub 1)

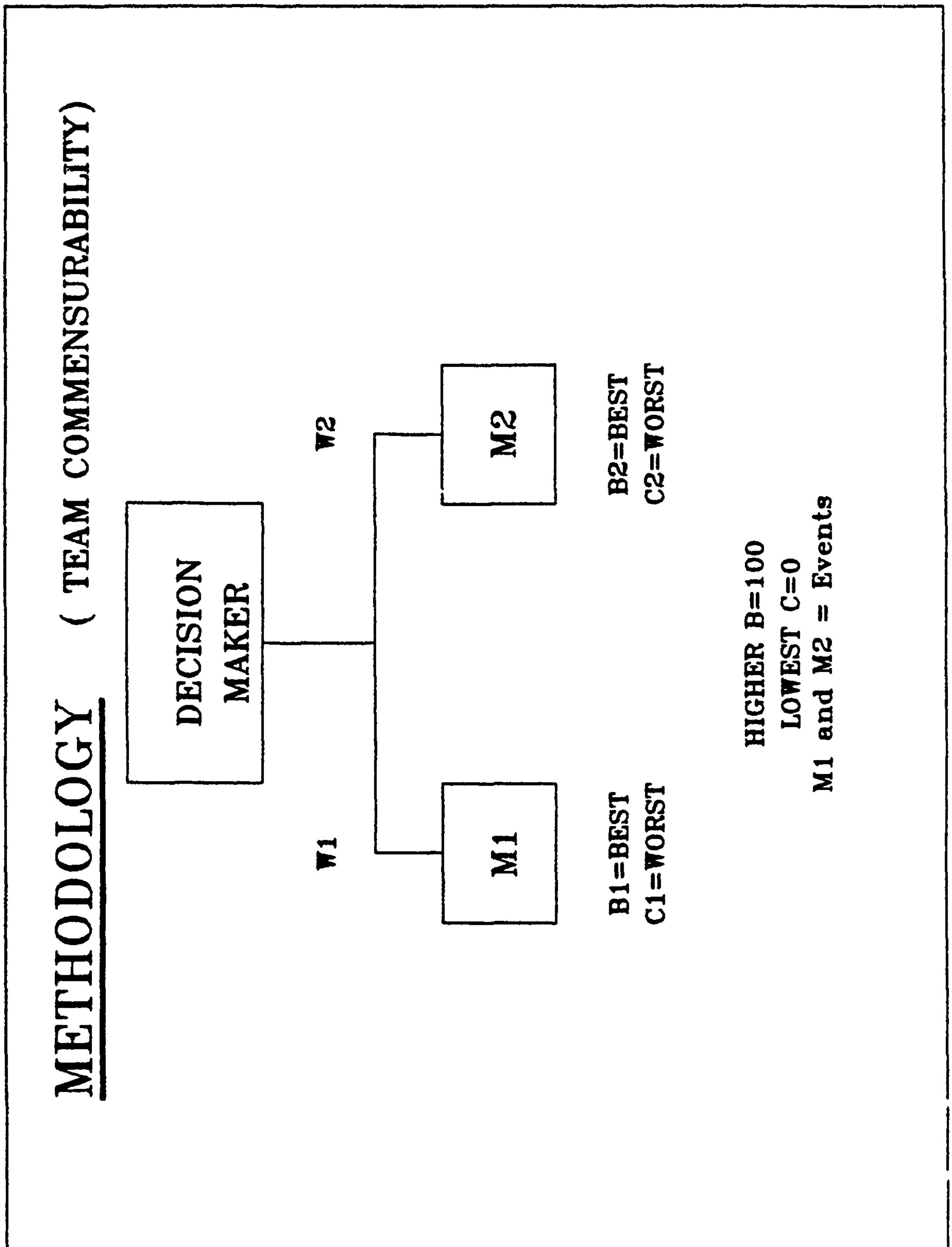
ELECTRONIC WARFARE (EW): Military action involving the use of electromagnetic energy to determine, exploit, reduce or prevent hostile use of the electromagnetic spectrum and action that retains friendly use of the electromagnetic spectrum.(JCS Pub 1)

SUPPRESSION ENEMY AIR DEFENSE (SEAD): That activity which neutralizes, destroys or temporarily degrades enemy air defenses in a specific area by physical attack and/or electronic warfare.(JCS Pub 1)

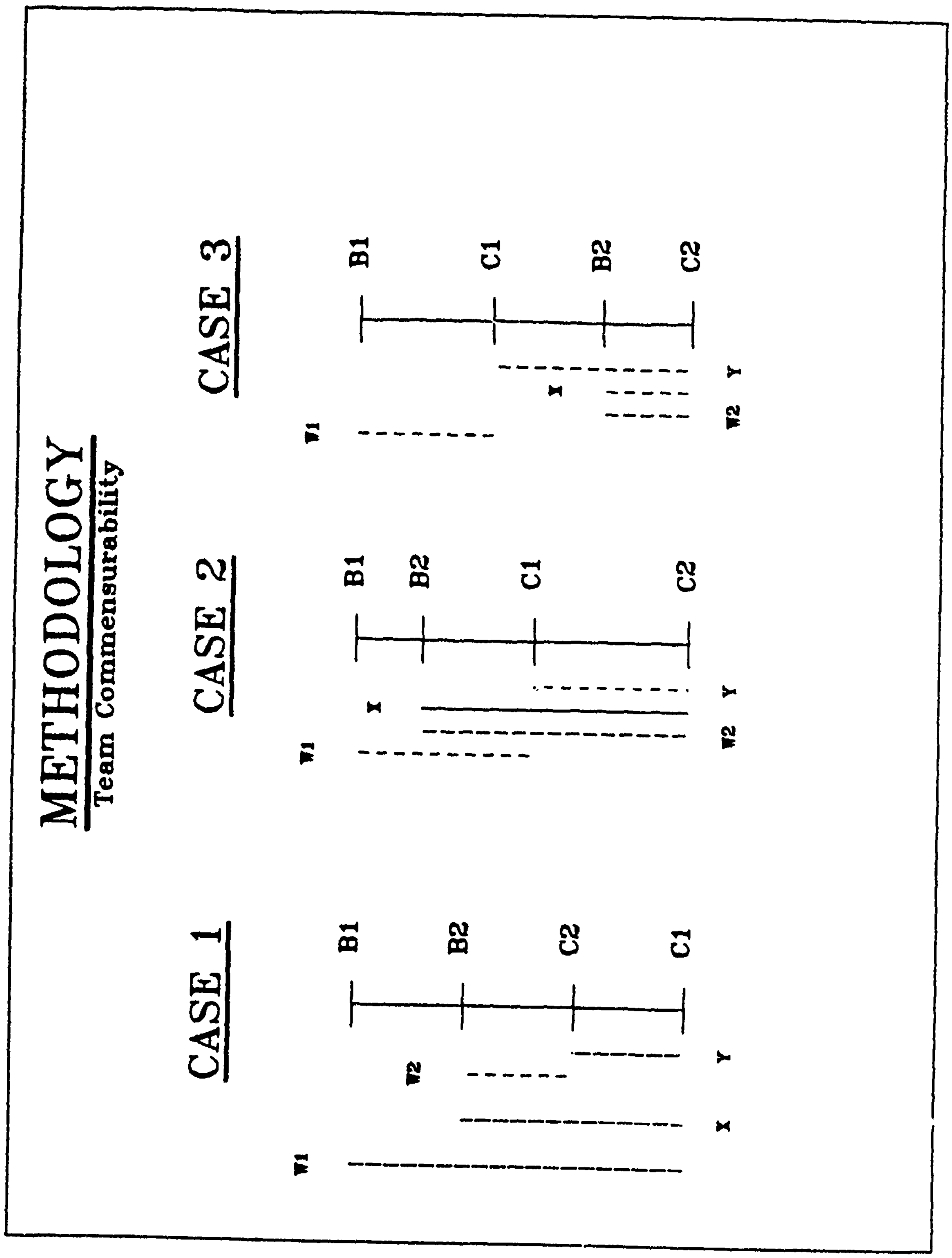
COMMAND CONTROL AND INTELLIGENCE (C2I)

An integrated system of doctrine, procedures, organizational structure, personnel, equipment, facilities and communications which provides authorities at all levels with timely and adequate data to plan, direct and control their activities.(JCS Pub 1)

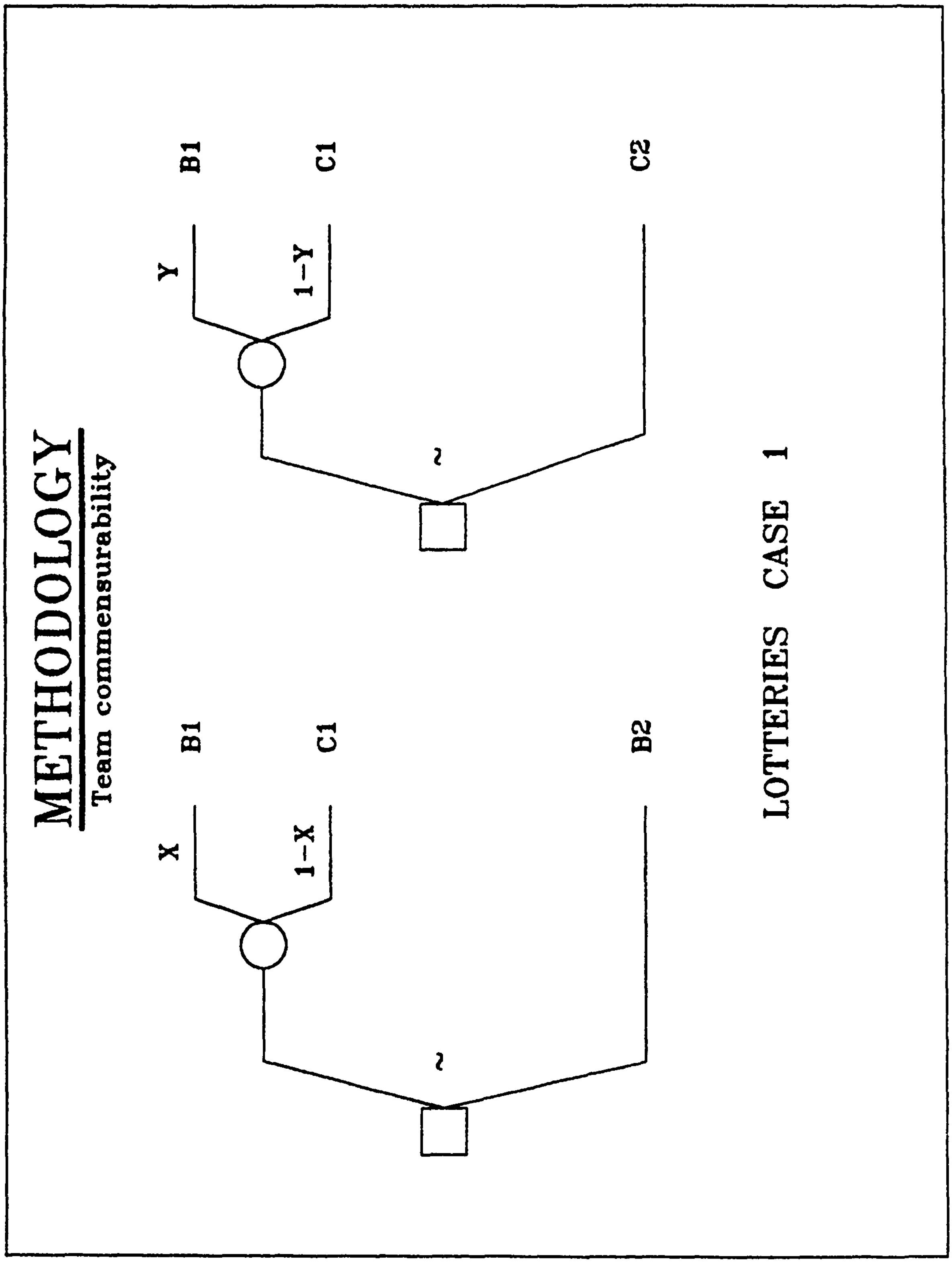
Appendix N. *Team Commensurability.*



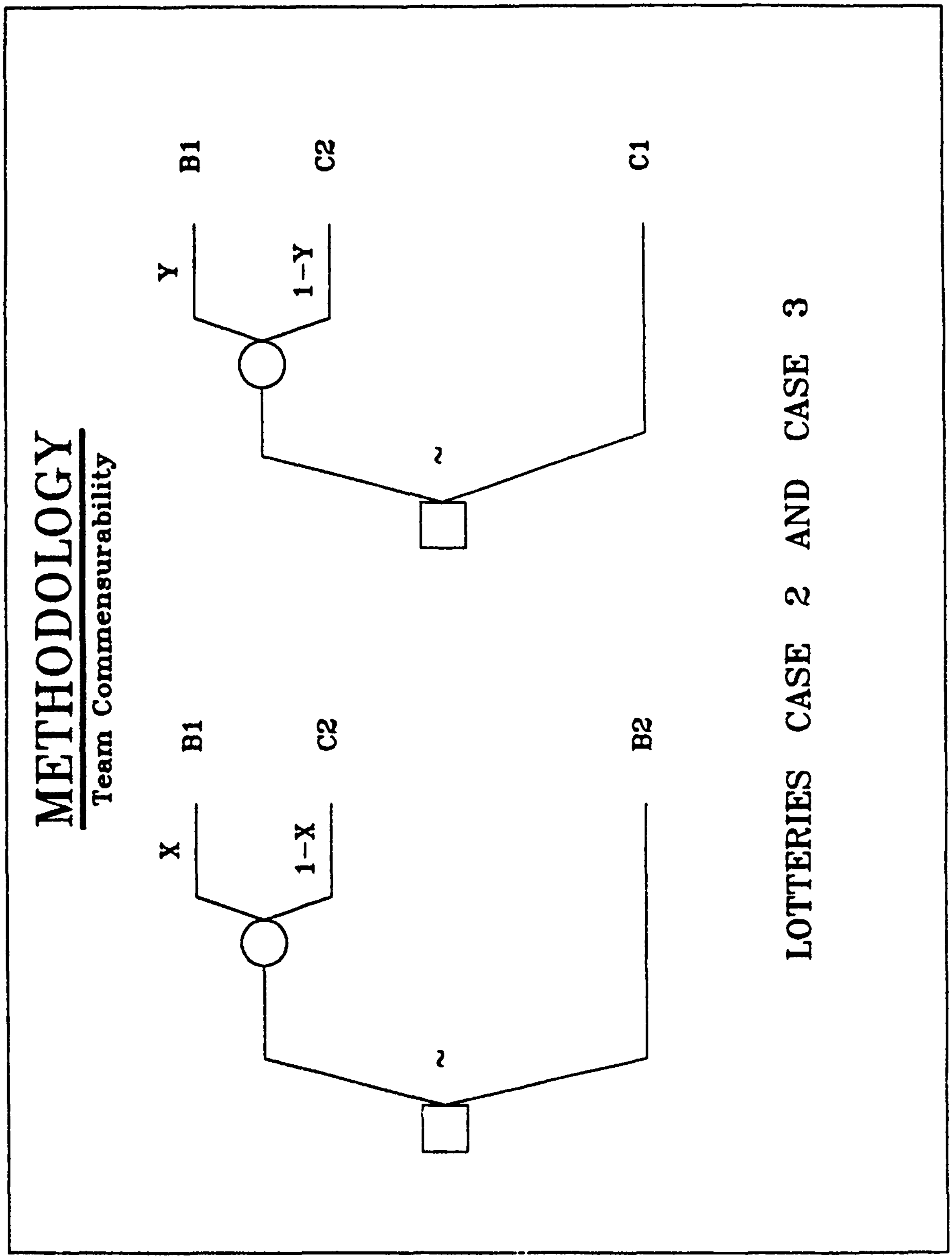
Different Cases.



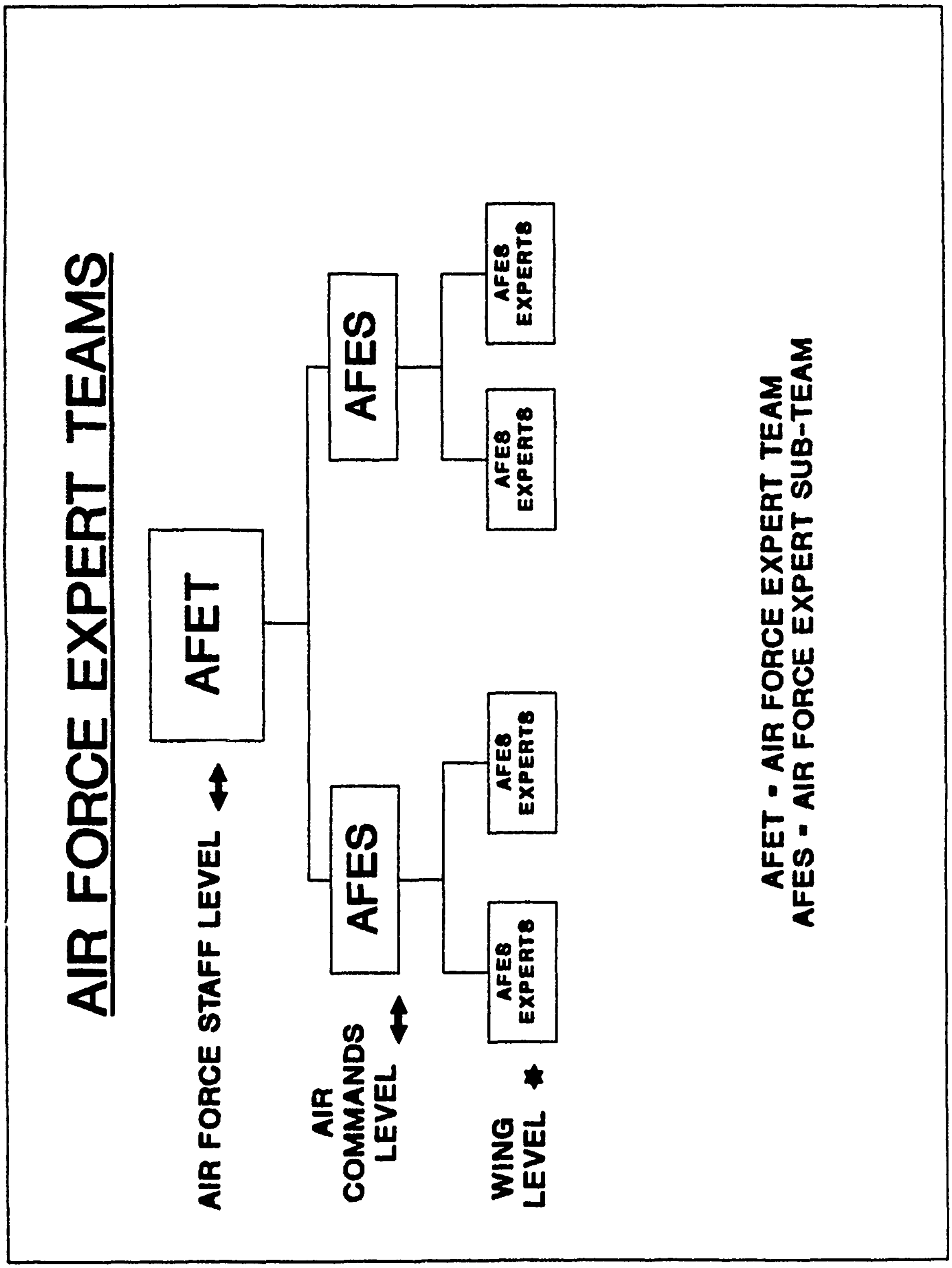
Lotteries Case 1.



Lotteries Case 2 and Case 3.



Appendix O. *Team Constitution.*



Appendix P. *Calibration of the Assessments.*

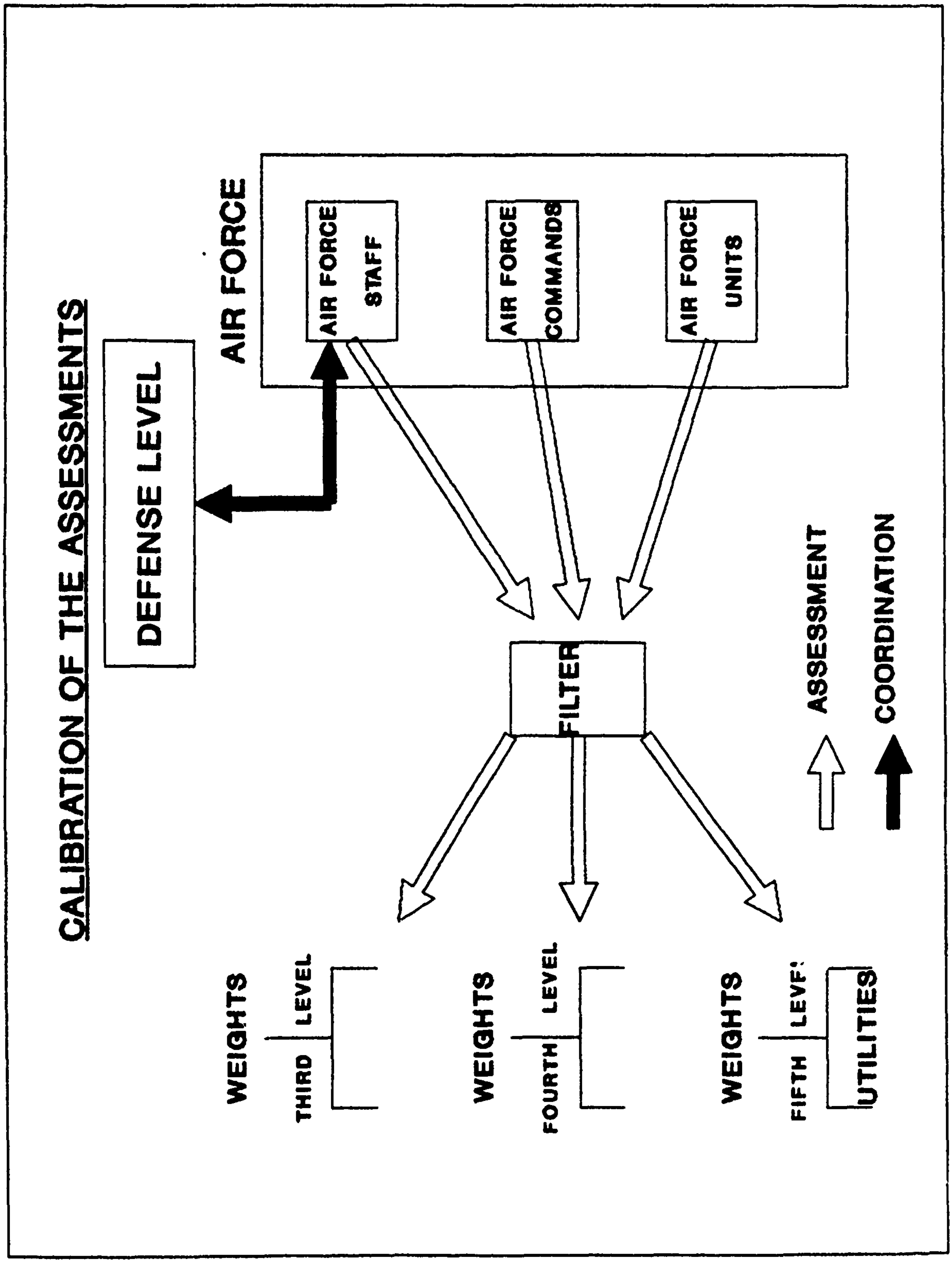


Table 1: Current Status I

CURRENT STATUS WEIGHTS														
	LEVEL 1: EAST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.100)	.300	.100	0	0	0	0	0	.100	.100	.050	0	.150	0	.200
AIR BAT. (.350)	.100	.250	.150	0	0	0	0	.100	.025	.025	.100	.100	0	.150
SURF. BAT. (.200)	.150	0	0	0	.150	.050	.150	.150	.100	.050	0	.100	0	.100
INTER. (.050)	.100	0	0	.250	0	0	0	.050	.050	.050	0	.200	.150	.150
C-OFFEN. (.100)	.150	0	.200	.050	.025	0	.025	.050	.025	.025	0	.200	.150	.100
AIRLIFT (.150)	.100	.150	.025	.025	.125	.025	.025	.200	.025	.025	.050	.1 00	.025	.100
S. OPER. (.050)	.200	.025	.025	.050	0	0	0	0	.200	.025	0	.200	.075	.200

Current Status - Weights - Table II.

Table 2: Current Status II

CURRENT STATUS WEIGHTS

	LEVEL 1: EAST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.100)	.200	.150	0	0	0	0	0	.200	.050	.050	0	.050	0	.300
AIR BAT. (.350)	.150	.300	0	0	0	0	0	.100	0	.050	0	.200	0	.200
SURF. BAT. (.250)	.100	0	0	0	.250	0	.200	.100	0	.050	0	.150	0	.150
INTER. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT (.150)	.300	0	0	0	0	0	0	.250	.100	.050	0	.150	0	.150
S. OPER. (.150)	.300	0	0	0	0	0	0	.050	.300	.050	0	.150	0	.150

Current Status - Weights - Table III.

Table 3: Current Status III

CURRENT STATUS WEIGHTS	LEVEL 1: WEST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.100)	.300	.100	0	0	0	0	0	.100	.100	.050	0	.150	0	.200
AIR BAT. (.300)	.300	.300	.050	0	0	0	0	.025	.025	.025	0	.125	0	.150
SURF. BAT. (.200)	.200	0	0	0	.200	0	.200	.025	.025	.025	0	.150	0	.175
INTER. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN. (.100)	.200	0	.200	0	.100	0	.100	.025	.025	.025	0	.225	0	.100
AIRLIFT (.200)	.200	.100	.050	0	.100	0	.100	.150	.050	.050	0	.100	0	.100
S. OPER. (.100)	.200	.100	.050	0	0	0	0	0	.250	.100	0	.100	0	.200

Current Status - Weights - Table IV.

Table 4: Current Status IV

CURRENT STATUS WEIGHTS														
	LEVEL 1: WEST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	FW	SEAD	C2I
C. CRISIS (.200)	.200	.200	0	0	0	0	0	0	.200	.025	.025	.050	0	.100
AIR BAT. (.500)	.200	.200	0	0	0	0	0	0	0	.100	.100	.200	0	.200
SURF. BAT. (.300)	.200	0	0	0	.300	0	0	0	0	.100	0	.200	0	.200
INTER. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. OPER. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Current Status - Weights - Table V.

Table 5: Current Status V

CURRENT STATUS WEIGHTS	LEVEL 1: SOUTH				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.100)	.300	.100	0	0	0	0	0	.100	.050	.050	0	.150	0	.250
AIR BAT. (.300)	.200	.150	.150	0	0	0	0	.050	.025	.025	.050	.150	.050	.150
SURF. BAT. (.200)	.200	0	0	0	.150	.100	.150	.050	.050	.050	0	.100	0	.150
INTER. (0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN. (.200)	.200	0	.200	0	0	0	0	.050	.025	.025	0	.100	.250	.150
AIRLIFT (.100)	.250	.100	.100	0	.025	.025	.025	.250	.025	.025	.025	.025	.025	.100
S. OPER. (.100)	.300	.100	0	0	0	0	.025	.025	.300	0	0	.025	.025	.200

Current Status - Weights - Table VI.

Table 6: Current Status VI

CURRENT STATUS WEIGHTS	LEVEL 1: SOUTH			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS (.200)	.250	.150	0	0	0	0	0	.100	.025	.025	0	.200	0	.250
AIR BAT. (.300)	.100	.250	.150	.100	0	0	0	.050	.025	.025	.050	.100	0	.150
SURF. BAT. (.150)	.125	0	0	.050	.150	.150	0	.125	.050	.050	0	.100	.150	.050
INTER. (.100)	.150	.100	0	.200	0	0	0	.100	.050	.050	0	.200	.100	.050
C-OFFEN. (.100)	.100	0	.200	.050	.025	0	.025	.050	.025	.025	0	.200	.150	.150
AIRLIFT (.100)	.100	.175	.125	.015	.010	.100	0	.150	.025	.025	.050	.10 0	.025	.100
S. OPER. (.050)	.200	.025	.025	.050	0	0	0	0	.200	.025	.050	.200	.025	.200

Appendix R. *Current Status - Utilities.*

Table 7: Current Status VII

CURRENT STATUS UTILITIES														
	LEVEL 1: EAST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.90	0	0	0	0	0	.90	.90	.85	0	.80	0	.80
AIR BAT.	.85	.90	.85	0	0	0	0	.85	.85	.85	.70	.85	0	.80
SURF. BAT.	.75	0	0	0	.80	.60	.80	.85	.70	.75	0	.70	0	.70
INTER.	.70	0	0	.75	0	0	0	.60	.60	.60	0	.60	.50	.50
C-OFFEN.	.75	0	.70	.75	.80	0	.80	.70	.70	.70	0	.75	.70	.60
AIRLIFT	.90	.85	.70	.60	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.65	.60	.40	.20	0	0	0	0	.70	.40	0	.60	.50	.60

Current Status - Utilities - Table VIII.

Table 8: Current Status VIII

CURRENT STATUS UTILITIES	LEVEL 1: EAST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.85	.85	0	0	0	0	0	.85	.85	.80	0	.70	0	.60
AIR BAT.	.80	.85	0	0	0	0	0	.80	0	.80	0	.70	0	.50
SURF. BAT.	.70	0	0	0	.70	0	.70	.80	0	.60	0	.60	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	.85	0	0	0	0	0	0	.80	.50	.50	0	.50	0	.50
S. OPER.	.60	0	0	0	0	0	0	.30	.70	.40	0	.40	0	.40

Current Status - Utilities - Table IX.

Table 9: Current Status IX

CURRENT STATUS UTILITIES	LEVEL 1: WEST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.85	.80	0	0	0	0	0	.80	.85	.85	0	.70	0	.70
AIR BAT.	.80	.70	.70	0	0	0	0	.75	.80	.80	0	.70	0	.55
SURF. BAT.	.60	0	0	0	.75	0	.80	.80	.60	.70	0	.60	0	.55
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.50	0	.60	0	.80	0	.80	.70	.50	.50	0	.60	0	.50
AIRLIFT	.70	.60	.50	0	.60	0	.60	.70	.40	.40	0	.60	0	.50
S. OPER.	.50	.50	.40	0	0	0	0	0	.60	.30	0	.50	0	.50

Current Status - Utilities - Table X.

Table 10: Current Status X

CURRENT STATUS UTILITIES	LEVEL 1: WEST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.70	.70	0	0	0	0	0	0	.70	.70	.50	.60	0	.60
AIR BAT.	.60	.60	0	0	0	0	0	0	0	.70	.50	.50	0	.50
SURF. BAT.	.70	0	0	0	.70	0	0	0	0	.70	0	.50	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. OPER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Current Status - Utilities - Table XI.

Table 11: Current Status XI

CURRENT STATUS UTILITIES														
	LEVEL 1: SOUTH				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.90	0	0	0	0	0	.90	.90	.85	0	.80	0	.90
AIR BAT	.90	.90	.85	0	0	0	0	.85	.80	.80	.80	.75	.85	.85
SURF. BAT.	.90	0	0	0	.90	.85	.95	.85	.75	.80	0	.70	0	.70
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.80	0	.70	0	0	0	0	.70	.70	.70	0	.80	.80	.60
AIRLIFT	.90	.85	.70	0	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.70	.70	0	0	0	0	.65	.70	.60	0	0	.70	.70	.60

Current Status - Utilities - Table XII.

Table 12: Current Status XII

CURRENT STATUS UTILITIES														
	LEVEL 1: SOUTH			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.85	.85	0	0	0	0	0	.80	.85	.85	0	.75	0	.80
AIR BAT.	.85	.80	.75	.60	0	0	0	.80	.75	.75	.80	.70	0	.75
SURF. BAT.	.85	0	0	.50	.80	.80	0	.80	.75	.75	0	.65	.70	.65
INTER.	.80	.70	0	.60	0	0	0	.60	.60	.60	0	.60	.65	.60
C-OFFEN.	.80	0	.70	.50	.75	0	.75	.65	.65	.65	0	.65	.70	.65
AiRLIFT	.80	.75	.75	.50	.50	.60	0	.65	.60	.60	.50	.60	.40	.60
S. OPER.	.60	.60	.50	.40	0	0	0	0	.70	.70	.40	.70	.70	.50

Appendix S. *European Fighter Aircraft (EFA) - Utilities.*

Table 13: EFA I

EFA UTILITIES

	LEVEL 1: EAST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.92	.98	0	0	0	0	0	.90	.90	.85	0	.95	0	.80
AIR BAT.	.90	.98	.90	0	0	0	0	.85	.95	.85	.70	.95	0	.80
SURF. BAT.	.75	0	0	0	.80	.60	.80	.85	.70	.75	0	.70	0	.70
INTER.	.80	0	0	.95	0	0	0	.60	.60	.60	0	.80	.60	.50
C-OFFEN.	.75	0	.85	.85	.80	0	.80	.70	.75	.75	0	.85	.75	.60
AIRLIFT	.90	.85	.70	.60	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.65	.60	.40	.20	0	0	0	0	.70	.40	0	.60	.50	.60

EFA - Utilities - Table II.

Table 14: EFA II

EFA
UTILITIES

	LEVEL 1: EAST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.95	0	0	0	0	0	.95	.85	.80	0	.85	0	.85
AIR BAT.	.85	.95	0	0	0	0	0	.80	0	.90	0	.90	0	.75
SURF. BAT.	.75	0	0	0	.70	0	.70	.80	0	.85	0	.90	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	.85	0	0	0	0	0	0	.80	.50	.50	0	.50	0	.50
S. OPER.	.60	0	0	0	0	0	0	.30	.70	.40	0	.40	0	.40

EFA - Utilities - Table III.

Table 15: EFA III

EFA UTILITIES

	LEVEL 1: WEST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.85	0	0	0	0	0	.80	.85	.85	0	.75	0	.70
AIR BAT.	.85	.80	.80	0	0	0	0	.75	.85	.85	0	.80	0	.55
SURF. BAT.	.65	0	0	0	.80	0	.80	.80	.60	.70	0	.65	0	.55
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.60	0	.70	0	.80	0	.80	.70	.50	.50	0	.65	0	.50
AIRLIFT	.70	.60	.50	0	.60	0	.60	.70	.40	.40	0	.60	0	.50
S. OPER.	.50	.50	.40	0	0	0	0	0	.60	.30	0	.50	0	.50

EFA - Utilities - Table IV.

Table 16: EFA IV

EFA UTILITIES

	LEVEL 1: WEST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.75	.85	0	0	0	0	0	0	.85	.70	.50	.80	0	.80
AIR BAT.	.70	.85	0	0	0	0	0	0	0	.85	.50	.85	0	.80
SURF. BAT.	.75	0	0	0	.70	0	0	0	0	.70	0	.55	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. OPER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EFA - Utilities - Table V.

Table 17: EFA V

EFA
UTILITIES

	LEVEL 1: SOUTH				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.95	.95	0	0	0	0	0	.90	.90	.85	0	.85	0	.90
AIR BAT.	.95	.95	.90	0	0	0	0	.85	.85	.85	.80	.80	.90	.85
SURF. BAT.	.92	0	0	0	.90	.85	.95	.85	75	.80	0	.75	0	.70
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.85	0	.75	0	0	0	0	.70	.75	.70	0	.85	.85	.60
AIRLIFT	.90	.85	.70	0	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.70	.70	0	0	0	0	.65	.70	.60	0	0	.70	.70	.60

EFA - Utilities - Table VI.

Table 18: EFA VI

EFA UTILITIES	LEVEL 1: SOUTH			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.95	.95	0	0	0	0	0	.80	.85	.85	0	.95	0	.90
AIR BAT.	.95	.98	.90	.85	0	0	0	.80	.90	.85	.80	.95	0	.85
SURF. BAT.	.90	0	0	.60	.80	.80	0	.950	.75	.75	0	.90	.75	.80
INTER.	.85	.90	0	.90	0	0	0	.60	.60	.60	0	.90	.85	.80
C-OFFEN.	.95	0	.90	.85	.75	0	.75	.65	.85	.70	0	.90	.75	.80
AIRLIFT	.80	.75	.75	.50	.50	.60	0	.65	.60	.60	.50	.60	.40	.60
S. OPER.	.60	.60	.50	.40	0	0	0	0	.70	.70	.40	.70	.70	.50

Appendix T. *Advanced Tactical Fighter (ATF) - Utilities.*

Table 19: ATF I

ATF UTILITIES	LEVEL 1: EAST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.98	.90	0	0	0	0	0	.90	.90	.85	0	.90	0	.90
AIR BAT.	.95	.95	.95	0	0	0	0	.85	.90	.85	.80	.90	0	.90
SURF. BAT.	.85	0	0	0	.90	.85	.80	.85	.80	.80	0	.85	0	.70
INTER.	.70	0	0	.75	0	0	0	.60	.60	.60	0	.60	.50	.50
C-OFFEN.	.75	0	.75	.75	.90	0	.80	.70	.70	.70	0	.85	.70	.60
AIRLIFT	.90	.85	.70	.60	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S.OPER.	.65	.60	.40	.20	0	0	0	0	.70	.40	0	.60	.50	.60

ATF - Utilities - Table II.

Table 20: ATF II

ATF UTILITIES	LEVEL 1: EAST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.85	0	0	0	0	0	.85	.85	.80	0	.75	0	.60
AIR BAT.	.85	.85	0	0	0	0	0	.80	0	.80	0	.75	0	.50
SURF. BAT.	.80	0	0	0	.90	0	.70	.80	0	.70	0	.85	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	.85	0	0	0	0	0	0	.80	.50	.50	0	.50	0	.50
S. OPER.	.60	0	0	0	0	0	0	.30	.70	.40	0	.40	0	.40

ATF - Utilities - Table III.

Table 21: ATF III

ATF UTILITIES														
	LEVEL 1: WEST				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.95	.80	0	0	0	[illegible]	0	.90	.95	.85	0	.75	0	.80
AIR BAT.	.85	.70	.75	0	0	0	0	.75	.80	.80	0	.80	0	.55
SURF. BAT.	.90	0	0	0	.95	0	.90	.80	.80	.80	0	.90	0	.85
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.90	0	.65	0	.90	0	.90	.70	.50	.50	0	.80	0	.70
AIRLIFT	.70	.60	.50	0	.60	0	.60	.70	.40	.40	0	.60	0	.50
S. OPER.	.50	.50	.40	0	0	0	0	0	.60	.30	0	.50	0	.50

ATF - Utilities - Table IV.

Table 22: ATF IV

ATF UTILITIES	LEVEL 1: WEST			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SC	SAR	BD	EW	SEAD	C2I
C. CRISIS	.75	.70	0	0	0	0	0	0	.70	.70	.50	.75	0	.60
AIR BAT.	.65	.60	0	0	0	0	0	0	0	.70	.50	.60	0	.50
SURF. BAT.	.85	0	0	0	.90	0	0	0	0	.80	0	.80	0	.50
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIRLIFT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. OPER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 23: ATF V

ATF UTILITIES

	LEVEL 1: SOUTH				LEVEL 2: NATO			LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.95	.90	0	0	0	0	0	.90	.90	.85	0	.90	(	.90
AIR BAT.	.95	.90	.90	0	0	0	0	.85	.80	.80	.80	.90	.90	.85
SURF. BAT.	.95	0	0	0	.95	.95	.95	.85	.85	.95	0	.95	0	.85
INTER.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-OFFEN.	.85	0	.80	0	0	0	0	.70	.70	.70	0	.90	.95	.70
AIRLIFT	.90	.85	.70	0	.70	.60	.80	.90	.60	.60	.60	.70	.50	.60
S. OPER.	.70	.70	0	0	0	0	.65	.70	.60	0	0	.70	.70	.60

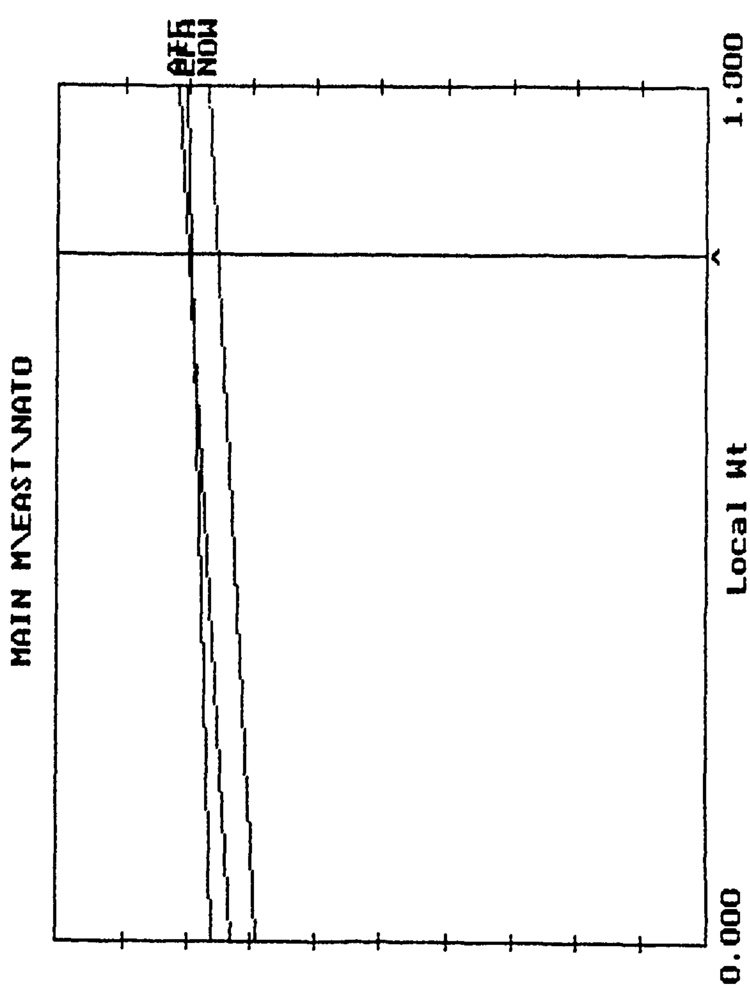
Table 24: ATF VI

ATF UTILITIES														
	LEVEL 1: SOUTH			LEVEL 2: NATIONAL				LEVEL 3: LOW L. CONFLICT						
	CR	AD	AO	AI	TAS	CAS	ASW	AL	SO	SAR	BD	EW	SEAD	C2I
C. CRISIS	.90	.85	0	0	0	0	0	.80	.85	.85	0	.90	0	.80
AIR BAT.	.90	.80	.80	.80	0	0	0	.80	.75	.75	.80	.85	0	.75
SURF. BAT.	.90	0	0	.70	.95	.95	0	.80	.85	.85	0	.85	.90	.75
INTER.	.85	.70	0	.70	0	0	0	.60	.60	.60	0	.80	.85	.65
C-OFFEN.	.85	0	.75	.65	.90	0	.75	.65	.65	.65	0	.80	.80	.65
AIRLIFT	.80	.75	.75	.50	.50	.60	0	.65	.60	.60	.50	.60	.40	.60
S. OPER.	.60	.60	.50	.40	0	0	0	0	.70	.70	.40	.70	.70	.50

Appendix U. *Demonstration - Sensitivity Analisys.*

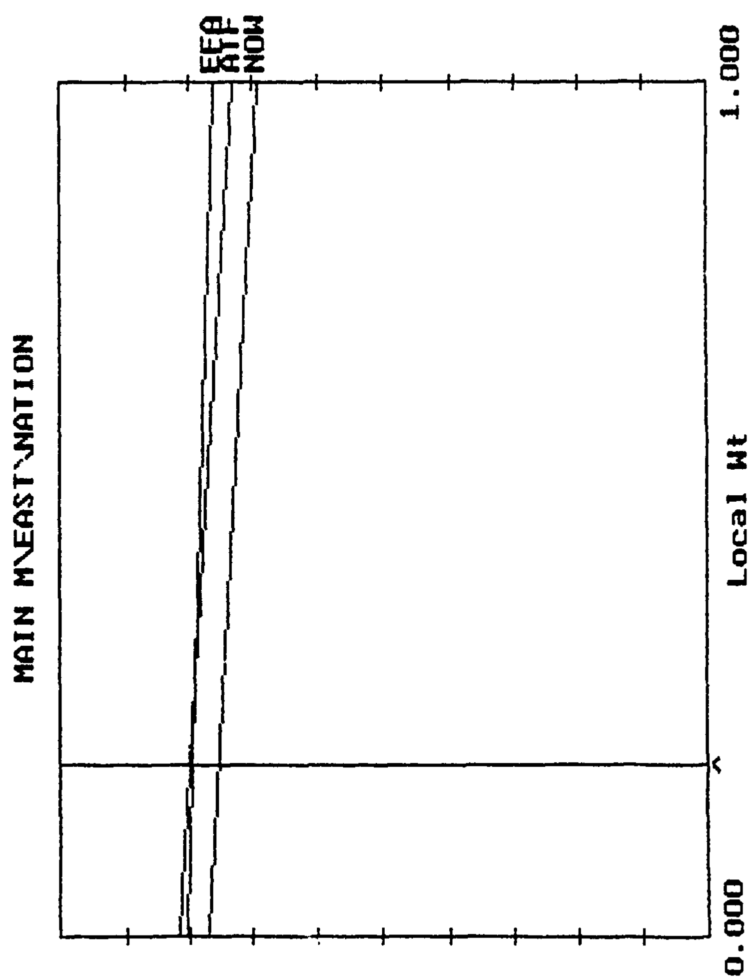
East Threat - NATO.

System	Low	High
NOW	0.689	0.765
EFA	0.760	0.800
ATF	0.728	0.816



East Threat - National.

System	Low	High
NOW	0.765	0.689
EFA	0.800	0.760
ATF	0.816	0.728



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